The Dissertation Committee for Sarah Adrienne Lang Certifies that this is the approved version of the following dissertation:

Stories of Staying and Leaving: A Mixed Methods Analysis of Biology Undergraduate Choice, Persistence, and Departure

Committee:

James P. Barufaldi, Supervisor

Ruth E. Buskirk

Anthony J. Petrosino

Stanley J. Roux, Jr.

Dee U. Silverthorn

Stories of Staying and Leaving: A Mixed Methods Analysis of Biology Undergraduate Choice, Persistence, and Departure

by

Sarah Adrienne Lang, A.B.; B.S.; M.A.

Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

May 2008

Acknowledgements

I would like to thank my family, friends, coworkers and professors for their enduring support during both my graduate education and the dissertation process. I would also like to thank the School of Biological Sciences and the UT Learning Center for keeping me funded. Lastly, I would like to thank the former and current biology students who participated in this study, especially those who took part in interviews.

Stories of Staying and Leaving: A Mixed Methods Analysis of Biology Undergraduate Choice, Persistence, and Departure

Publication No._____

Sarah Adrienne Lang, Ph.D.

The University of Texas at Austin, 2008

Supervisor: James P. Barufaldi

Using a sequential, explanatory mixed methods design, this dissertation study compared students who persist in the biology major (persisters) with students who leave the biology major (switchers) in terms of how their pre-college experiences, college biology experiences, and biology performance figured into their choice of biology and their persistence in or departure from the biology major. This study combined 1) quantitative comparisons of biology persisters and switchers via a questionnaire developed for the study and survival analysis of a larger population of biology freshmen with 2) qualitative comparison of biology switchers and persisters via semi-structured life story interviews and homogenous focus groups. 319 students (207 persisters and 112 switchers) participated in the questionnaire and 36 students (20 persisters and 16 switchers) participated in life story and focus group interviews. All participants were undergraduates who entered The University of Texas at Austin as biology freshmen in the fall semesters of 2000 through 2004. Findings of this study suggest: 1) Regardless of

eventual major, biology students enter college with generally the same suite of experiences, sources of personal encouragement, and reasons for choosing the biology major; 2) Despite the fact that they have also had poor experiences in the major, biology persisters do not actively decide to stay in the biology major; they simply do not leave; 3) Based upon survival analysis, biology students are most at-risk of leaving the biology major during the first two years of college and if they are African-American or Latino, women, or seeking a Bachelor of Arts degree (rather than a Bachelor of Science); 4) Biology switchers do not leave biology due to preference for other disciplines; they leave due to difficulties or dissatisfaction with aspects of the biology major, including their courses, faculty, and peers; 5) Biology performance has a differential effect on persistence in the biology major, depending on how well students perform in comparison to other courses or other students.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

STATEMENT OF THE PROBLEM

Undergraduate attrition from the biological sciences is both a poorly-studied and complex phenomenon. Although there have been several studies addressing departure from science, technology, engineering, and mathematics (STEM) disciplines, none has specifically concentrated on biology. Because biology is the most popular of STEM disciplines and the one that suffers the greatest losses of individuals, research into departure from and persistence in the major is an imperative.

BACKGROUND

For the past three decades, several research groups have reported a decline in the number of freshmen entering various STEM majors, and more importantly a decline in the number of students retained in these majors (Astin & Astin, 1993; C-IDEA, 2001; Green, 1989; National Science Board, 2008; Seymour & Hewitt, 1997). Using longitudinal data from national samples collected through the Higher Education Research Institute (HERI), for example, Astin and Astin (1993) showed a 40% decline in the number of students interested in STEM majors between high school and freshman year; and a 50% decline in the number of STEM majors between the freshman and senior years of college. Similarly, using data from its study institutions, the Center for Institutional Data Exchange and Analysis (2000) found that approximately 50% of students with an initial STEM major switched to a non-STEM major within the first two years of enrollment. Moreover, their most recent six-year graduation data demonstrates that only

39.6% of the 2001 cohort of students initially committed to a STEM major graduated with a STEM degree (S. Whalen,[1] personal communication, February 6, 2008).

Attrition from the biological sciences is a particularly complex case because departure from the major is masked by the simultaneous front-loading of freshmen into the major. Whether due to students' familiarity with biology[2] and/or the lure of the medical profession, biology is the fourth most popular major nationally (Princeton Review, 2007) and, since the 2003-2004 academic year, the most popular major at the study institution, based both upon enrollment and degrees awarded (Office of Institutional Research, 2007a; 2007b). Despite or because of this popularity, biology historically loses more students than any other STEM major. Astin & Astin (1993) showed a 57.5% decline in the number of biology majors between freshman and senior years of college, with the majority switching to non-STEM disciplines. Similarly, the National Science Board (2008) showed a 51.1% decline among the 115,300 agricultural/biological science majors who began college in 1995. By 2001, 42.0% had switched to a non-STEM major and 9.1% had switched to a different STEM major. Consistent with these statistics are those from the study institution: for the freshmen who entered as biology majors in the fall semesters of 2000 through 2002 and persisted through to a degree[3] (n=1321), the rate of retention in the biology major was 55.2%. Of the remaining 44.8% who left the biology major, 31.4% switched to non-STEM majors, and 13.4% switched to a different STEM major (College of Natural Sciences, 2006a).

---

[1] Sandra Whalen is the Project Manager for the Consortium for Student Retention Data Exchange (CSRDE), which is a sponsored by the Center for Institutional Data Exchange and Analysis (C-IDEA).

[2] In Texas, the minimum science requirement includes one year of biology and one year of integrated physics and chemistry (IPC), such that all high school graduates have had at least one year of biology in high school. Moreover, with the inclusion of environmental science and anatomy and physiology as electives and a second year of biology for juniors and seniors at many high schools, students may take several semesters of biological science before graduating. (Texas Education Agency, 2005)

[3] Of the original 1654 students, 333 or 20.1% dropped out or were dismissed. This dropout/dismissal rate is consistent with that of the entire University. Note that dropouts include students who transferred to other institutions (Office of Institutional Research, 2007c).

On the outset, these statistics do not seem alarming, especially to those who believe it is important to "weed out" students ill-equipped to handle biology. However, if we assume that students who switch from biology to another STEM major do so mainly out of preference and that students who leave college altogether do so because of reasons beyond those associated with their major, then the rate of switching to non-STEM majors should not be any greater than the rate of switching to other STEM majors. These statistics imply that something besides student preference has caused approximately 18%, or 238 biology students to leave science altogether.

Exacerbating the problem of attrition from STEM majors is that the rate of departure is not being offset by the recruitment of new STEM students during the college years (Astin & Astin, 1993). Strenta, Rogers, Russell, Matier, and Scott (1994) showed that not only were the losses from science majors greater than those from non-science majors, but the transfer rate for science majors to non-science majors was considerably higher than the reverse. For example, they found among students who reported an initial interest in biology, 41% completed a biology degree, 47% switched to social sciences or humanities, and 7% switched to other STEM majors; whereas among students who reported an initial interest in social science, 88% completed a social science or humanities degree, 4% switched to biology, and 3% switched to other science or engineering majors.[4] Graduation data from the study institution is consistent with these findings: of the 1057 biology students who graduated between 2003 and 2006 and had entered The University with a declared major, 76.2% entered college as biology majors, 18.4% started in other STEM majors, and only 5.4% started in non-STEM majors (College of Natural Sciences, 2006b).[5] Statistics such as these demonstrate the poor

[4] In both cases, 5% dropped out of college (Strenta, et. al., 1994).

[5] Even with undeclared freshmen included (n=333), 58% of graduates entered as biology majors; 30.2% came from other STEM majors; and 11.8% came from non-STEM majors. Note that at the study

recruitment of students from other disciplines and that, at least at the study institution, the majority of biology graduates chose their major prior to matriculation.

Complicating the above problems is that the losses appear to continue after college graduation. Data from the National Survey of Recent College Graduates (National Science Foundation, 2003) demonstrates that only 13.2% of the 125,000 biological sciences bachelor's recipients from 2001 and 2002 were employed in science occupations in 2003. The remaining graduates were either full-time students[6] (45.9%), employed in science-related occupations including healthcare (9.3%), employed in non-science occupations (26.3%), or unemployed (6.1%). Given that post-graduate employment, whether in or out-of-field, is not necessarily an indication of future career commitment and there unknown job market factors affecting employment in-field, it is still worrisome that there were more graduates employed in non-science occupations than both science and science-related occupations combined.

Therefore, with a substantial portion of students leaving STEM majors during or after college and an insignificant number of students filling those vacant spots, this results in a net leakage from the STEM pipeline (Seymour & Hewitt, 1997). The most noticeable effect of this leakage is that there have been concomitant shortages in primary health care, certain allied health professions, some engineering professions, and, most importantly, science, technology and mathematics education in the past two decades (Bureau of Health Professions, 2003; Ingersoll, 2003a; Office of Postsecondary Education, 2007; Seymour & Hewitt, 1997). In the case of biology education, Ingersoll (2003a) found that 46% of US secondary schools had vacancies for life sciences teachers

---

institution, undeclared students were still registered under a particular college (e.g. undeclared natural sciences, undeclared liberal arts, etc.) so they could be categorized as STEM or non-STEM.

[6] Note that these statistics do not differentiate between advanced degrees in STEM disciplines and those in other disciplines, so some unknown portion of these graduates sought degrees outside of the biological sciences.

and over half of these schools have difficulty filling these vacancies. Similarly, data from the most recent Teacher Shortage Area report shows that, of the 47 states[7] reporting teacher shortages from 2005 to 2007, 36 reported shortages in high school science, including biology (Office of Postsecondary Education, 2007). Aggravating the teacher shortage problem is that a considerable portion of currently-employed life science teachers are not academically prepared to teach. According to the National Center for Education Statistics, in 2000 approximately 45% of high school biology teachers were teaching biology without a degree or certification in the life sciences and another 10% were teaching biology without a degree, certification, or minor in the life sciences (Seastrom, Gruber, Henke, McGrath, & Cohen, 2002). Similarly, Ingersoll (2003b) found that, during the 1999-2000 school year, 36.8% of high school life science teachers had neither a major or minor in biology.

RATIONALES FOR THE STUDY

There are two major rationales for my dissertation study: one related to scope and the other related to inclusiveness. First, while there are many theories and studies of student departure from college, there has been relatively little research into the reasons why students leave STEM majors for non-STEM majors. Moreover, none of this research has specifically addressed the biological sciences, and has instead attempted to uncover the overarching reasons students leave STEM disciplines in general. Since the various STEM disciplines are theoretically and practically diverse and students may or may not be familiar with these disciplines prior to matriculation, student departure from STEM majors should be studied in a discipline-specific manner.

Second, most research of student departure from or avoidance of STEM disciplines centers upon students who are 'high-ability' as indicated by their SAT scores

[7] Including The District of Columbia

or grades (Manis, et.al., 1989, Seymour & Hewitt, 1997; Strenta, et.al., 1994; Tobias, 1990), the rationale being that the loss of high ability students constitutes the loss of able science students. Not only does this emphasis belie the "Science for All" initiatives in place at the elementary, middle, and high school level, and as advocated by organizations such as the American Association for the Advancement of Science (AAAS, 2005), the exclusion of "lower-ability" students, particularly persisters, from these data sets unwittingly supports the idea that weeding out students to make room for the more capable students is somehow acceptable. Rather than lament the loss of higher-performing students, we as researchers should uncover the beliefs that allow lower-performing persisters to keep going despite the odds. Identifying why students persist is as important, if not more important, than identifying why students switch.

Therefore, the rationales for my dissertation are to add to the research of departure from the sciences by uncovering why students specifically leave biology, and how performance factors into both persistence and departure.

THEORETICAL FRAMEWORK

Because there have been relatively few studies of student departure from science majors,[8] and none has proposed a testable model for said departure, the theoretical context of this study resides within the larger area of institutional departure research, for which many models exist.[9] Although any one of these models could describe some portion of student departure from STEM majors, most emphasize institutional sources of departure, presumably because they are aimed at helping institutions develop or evaluate retention programs. While it is certainly the case that institutions have a role in both

[8] Astin & Astin (1993), Green (1989), Manis, et. al.. (1989), Seymour and Hewitt (1997), Strenta, et. al. (1997), and Packard (2005), among others

[9] Major and well-studied models include Astin's Theory of Involvement (1985); Bean's Model of Work Turnover (1980, 1983), and Tinto's Theory of Individual Departure (1993), among many others.

departures from college and from STEM majors, these models unintentionally minimize the role of the student. Because students are making decisions about their major, usually without any intervention on the part of the institution, the student should be central to any model describing departure from STEM majors.

As such, this study utilizes Stage and Hossler's (2000) Student-Centered Theory of Persistence, which has five overlapping and interacting elements: 1) background and family involvement, 2) pre-college academic experiences, 3) intentions and engagements with regard to college and preparation for college, 4) college entry and social and academic involvement, and 5) persistence or dropout. Many of these constructs are similar to the other models of student departure; where the model differs is the emphasis and relative importance of each construct.

Although this model was developed for undergraduate persistence in college as determined by decisions surrounding college choice, it is very congruent with discussions of student persistence in science as determined by major choice. First, because Stage & Hossler's model is grounded in both Fishbein & Azjen's (1975) behavioral intentional model and Bandura's (1977, 1997) construct of self efficacy, it is predicated on the idea that college students, as adults, are active participants in both their education and the decisions they make therein. Fishbein and Ajzen (1975) proposed that intentions precede behaviors and those behaviors are influenced by both attitudes and social norms. Bandura (1977, 1997) proposed that mastery experiences, the vicarious experiences of peers, the verbal persuasion of significant persons, and emotional engagements connected to activities provide individuals with evidence to make decisions, select goals and tasks, and form beliefs about their abilities. Together, these theoretical constructs position persistence or departure as a decision rather than a reaction. Secondly, unlike other models, Stage & Hossler's emphasizes the importance of student-initiated, rather than

institution-initiated, involvement in the academic and social realms of college. This aligns with Stage & Hossler's (2000) positioning of students as active participants, emphasizing both the importance of student behavior and choices, as well as the analysis of resource use rather than resource presence.

PURPOSES OF THE STUDY

The purposes of this sequential explanatory mixed methods study were to: 1) explore the differences and similarities between biology switchers and persisters with respect to their pre-college and college experiences, including how they chose the biology major; 2) explore how performance and other factors play into persistence and departure; and 3) use the stories of biology switchers and persisters to understand how students make decisions regarding biology persistence and departure.

RESEARCH QUESTIONS

1. How do biology persisters and switchers compare in terms of:
    a. Demographic characteristics?
    b. Precollege experiences with science?
    c. Sources of encouragement with regards to biology?
    d. Their decision process with regards to major choice?
    e. Their experiences in and perceptions of the biology major?
    f. The role that performance plays with regards to their persistence or departure?
2. Why do biology persisters stay in the biology major?
3. Why do biology switchers leave the biology major?

LIMITATIONS

Data Contamination

Because this was an *ex-post facto* study, the data were not only potentially contaminated by the accuracy of participants' memory, but also their present circumstances. As with any study relying upon participant recall of events, there was the potential that students' present beliefs and experiences could taint their understanding or perception of past events. While it would have been ideal to limit this effect by performing a longitudinal study tracking a single cohort of students from college entrance to graduation, this was not feasible due to the time constraints associated with a dissertation and the higher probability of participant drop-out in a longitudinal study.

Sample Size

Because of the nature of the study, it was difficult to recruit student participants, particularly among switchers. This caused a significant disparity in the number of persisters and switchers completing the questionnaire, as well as volunteering for interviews. This problem, in conjunction with a higher rate of no-shows among switchers, also resulted in a disparity within focus groups (7 switchers versus 12 persisters). The sample size problem among switchers is probably related to their reluctance to discuss their experiences in the biology major, which brings into question the external validity of data concerning switchers. In addition, there was no way to statistically account for differences in sample size due to the use of non-parametric analysis, which were required due to the non-normal distribution and categorical nature of the data. To account for this, I performed t-tests for each of the Mann-Whitney analyses to ensure that, when assumptions for equal variance were violated, the statistical significance for both tests were similar (significant versus not-significant). The t-tests, on

average, produced a greater number of significant results than the Mann-Whitney tests, which means that the Mann-Whitney tests were more conservative in measuring differences between groups.

Exclusivity of Participants and Research Site

Because this study does not include students who chose to major in biology after their first semester of college, the findings may not be generalizable to students who choose to major in biology later in their academic career. As further described in Chapter 3, the reason for this delimitation was to remove potentially confounding variables from the data set and prevent data contamination by incidental biology majors, those who major in biology after not being admitted to pharmacy school or after leaving another natural science major. Furthermore, because the location of the study was a large, Research One institution, the findings may not be generalizable to liberal arts colleges or smaller universities. This is particularly true for ones that expect students to take general education requirements during their first year of college and choose their major during the second semester of their sophomore year.

TERMS

Biology persister – a biology student who persists in biology (see persister)

Biology switcher – a biology student who leaves biology (see switcher)

Non-STEM – disciplines outside of science, technology, engineering and math

Non-STEM switcher – a biology student who leaves for a non-STEM major

Non-switcher – same as a persister, used by some authors

Other STEM switcher – a biology student who leaves for a different STEM major

Persister – a STEM student who persists in their chosen STEM major

STEM – science, technology, engineering, and math disciplines

Switcher – a STEM student who leaves their chosen STEM major

ORGANIZATION OF THE DISSERTATION

This dissertation is divided into five chapters, the first of which is this introductory chapter. Chapter 2 (Review of Literature) provides a synopsis and integration of research into both STEM major choice and departure. Chapter 3 (Methodology) describes the research design as well as the analytical procedures used in this study. Chapter 4 (Results) presents both the quantitative and qualitative results in chronological order. Chapter 5 (Discussion and Conclusions) presents a summary, integration, and discussion of the major findings, as well as comparison of the data to the model presented in this chapter.

Chapter 2: Review of Literature

The research summarized in the following chapter is divided into two parts: research of students' major choice and research of college student persistence in science, technology, engineering, and mathematics (STEM) majors.

RESEARCH INTO STUDENTS' MAJOR CHOICE

Although there are have been several studies into undergraduates' choice of major, the aim of these studies has been to reveal or validate the factors[10] that predict students' academic tendencies, most often by utilizing regression analysis. While this information is useful for academic and career counselors, it is less useful for researchers investigating undergraduate outcomes, including STEM retention. Aside from this research, there have been few studies of how or why students choose college majors. Feldman, Smart, and Ethington (1999) propose that the lack of research into major choice is due to an overall neglect of the topic, rather than the likelihood that major choice has little to do with student outcomes.

> The ostensive decline in the influence of academic departments and major fields on students' abilities and interests may be less a fact of reality and more an artifact of certain methodological decisions of researchers as well as their failure to classify departments in theoretically meaningful and empirically defensible ways in their efforts to understand differential patterns of change and stability of students in disparate academic departments (Feldman, et. al., 1999, p. 642).

Despite this overall lack of research, there is one line of major and career choice research directly related to the current study, that which exists within the greater realm of research

[10] Factors studied have included personality types (Feldman, et.al, 1999, 2001; Porter & Umbach, 2006); SAT scores (Turner & Bowen, 1999); expected earnings for different careers (Montmarquette, et.al, 2002); high school course enrollment (Trusty, 2002); role-model effects (Canes & Rosen, 1995; Rask & Bailey, 2002); student perceptions of the labor market (Hu, 1996); beliefs about the certainty of knowledge (Trautwein & Lüdtke, 2007); and hundreds of input, environmental, and output various, including several of the above (Astin & Astin, 1993).

into retention in STEM majors. In these studies, most notably those of Manis, Sloat, Thomas, and Davis (1989) and Seymour and Hewitt (1997), student major choice was part of a larger discussion of leaving decisions.

Using structured surveys, Manis and colleagues (1989) studied the major choice of 530 first-year female students with either an interest in science or an SATM[11] score of at least 550 about their initial interests and major choice. Four years later, they asked 213 of these women, 85 others who had not responded to the first questionnaire, and 124 senior men with matched abilities and interests, how their plans had changed during their undergraduate education. The authors divided the respondents into groups based upon gender and major and compared their survey results.

The authors found that women and men were strikingly similar in their reasons for their major choice. In descending order of prevalence, the top reasons participants chose their major were: 1) personal enjoyment or interest; 2) own talent in the field; 3) importance of the field as preparation for intended profession or career; 4) previous high school courses; 5) the influence of a family member; and 6) a strong background in the field.[12] However, there were noticeable differences between students in science majors and those in non-science majors. Students in science majors rated their previous high school experiences, high school teachers, and family members as more important factors in their decision than did students in non-science majors. Moreover, students in science majors more often reported that they had strong backgrounds in the field and that their major choice was important for their career goals. In either case, these are not surprising results considering that very little of the humanities and social sciences, except English, government, history and the occasional elective, are taught at the high school level.

[11] SATM refers to the mathematics section of the Scholastic Aptitude Test (SAT)
[12] Where women and men differed was in their ratings of the fifth and sixth reason, with women reporting them in the order shown and men reporting them in the opposite order.

Seymour and Hewitt (1997) used an ethnographic approach to understand both students' major choice and their reasons for persisting in or leaving their major, using both interviews and focus groups. They interviewed 335 American-born college juniors and seniors, 183 of whom were switchers and 152 of whom were non-switchers. The authors over-sampled for undergraduates who are traditionally under-represented in STEM majors, specifically minority students and women. They also selected students from seven colleges and universities, including ones from different geographic areas and both public and private institutions. An additional 125 students from six other campuses were selected for three to five member focus groups. Based upon criteria provided by the authors, the institutions randomly selected all participants. All participants had earned a 650 or better on the SATM, and all had declared a science, math, or engineering major upon entrance to college.

Based upon the themes collected from interviews with switchers and non-switchers, Seymour and Hewitt (1997) found six major reasons for students' initial major choice. Based upon the author's coding scheme and not their raw data, in order of the prevalence of these responses, students chose their major due to: 1) uninformed choices; 2) the active influence of others; 3) intrinsic interest; 4) pragmatism/materialism; 5) too few or too many options and 6) altruism. As the authors explain, "uninformed choices" included basing major choices on childhood dreams, prior performance in math and science in high school, a family tradition, and presumed career goals. The authors labeled these as uninformed choices partly because of the wording of the informants themselves, but also because the vast majority of the informants who made choices such as these switched out of their major. The "active influence of others" meant that the students were persuaded, or even pressured, into their STEM major by a person of significance to them, including family members and teachers. Intrinsic interest meant

that the student chose their major because of an enjoyment or interest in the discipline. Pragmatism/materialism meant that students chose their STEM major for financial gains, prestige, or to obtain employment in stable or competitive fields. Too few or too many options included students who chose their major as a compromise or reported that they chose their major out of a great number of majors that they found interesting or applicable to their experiences. Lastly, altruism referred to a desire to help others or make a difference with their degree or future career.

Like Manis and colleagues (1989), Seymour and Hewitt (1997) also found some clear differences between switchers and non-switchers. They found that non-switchers were more likely to report they chose their major out of intrinsic interest, and by extension, altruism; whereas switchers were more likely to have chosen their major based upon the active influence of others, materialism and pragmatism, and uninformed choices. The authors claim that, because the decision to leave a major or stay in a major is multi-faceted, there is no way to determine if the trends they found in students' major choice were important in switching decisions.

There are two drawbacks to these studies: one related to analysis and one related to methodology. First, none of the authors discussed student major choices as a consequence of the limited scope of high school education, which concentrates on a small subset of the subjects available in college. Although Seymour & Hewitt (1997) determined that uninformed choices of major included those based upon prior performance in high school, they did not seem to consider the possibility that, because of high school, all of their choices would be uninformed. Similarly, when discussing choices based on interest, neither Seymour and Hewitt (1997) nor Manis and colleagues (1989) discussed that this interest was shaped in the high school environment, namely one of limited options and poor exposure to the fields available in college. Second,

because each of the studies positioned initial major choice as adjunct to understanding students' final major choice, neither of the sets of investigators determined the weight of the initial major choice on switching decisions. Therefore, while negative instructional and curricular factors were important in switching decisions in both studies, as discussed in the next section, this leaves ample room for the possibility that these instructional interferences only worked to exacerbate an already existent problem, namely that the initial major choice was an uninformed choice.

RESEARCH INTO DEPARTURE FROM STEM DISCIPLINES

There are three major problems connected to STEM departure research, each of which has consequentially affected the amount and scope of this research. First, there exists an undercurrent at colleges and universities that it is somehow acceptable that students leave STEM majors, that the process of weeding-out students is appropriate. Secondly, because of a need to discredit the above assumption, the majority of the research in this area avoids issues related to the student, such as motivation, comprehension, or perceptions of performance, and rather concentrates on the institutional factors related to switching decisions. Third, although there are newer data sets in circulation (see Chapter 1) even the more current research relies on data that is well over a decade old. Last, investigations into reasons for student departure have most often ignored why certain students persist in STEM majors, leaving the story incomplete.

The first of these problems is that undergraduate faculty and departments consider attrition in these majors as acceptable, particularly in the context of introductory courses. As Seymour and Hewitt (1997) note, the loss of a sizable proportion of students is part of a "weed-out" mentality at colleges and universities, such that the purposeful rigor of STEM courses is not only to adequately prepare students for later coursework, but also to remove presumably academically-deficient or less-interested students from the major

prior to enrollment in later coursework. Seymour and Hewitt (ibid.) call this a "cruel to be kind" measure in which weeding out students by allowing them to figure out that they are in the wrong major earlier, prevents students from wasting time or effort working toward a degree they may not actually want (p. 393). The authors note that coincident to this assumption is the idea that students voluntarily leave science majors due to poor performance or because they become interested in something else, rather than because they are pushed out of the major for reasons not entirely under their control. Thus begins a self-sustaining cycle, in which students are taught by faculty who adopt the assumption that switching out of STEM majors is acceptable. The students, in turn, adopt the same assumption, whether by example or by practice, and then some of the students that persist become faculty themselves. The problem with this assumption is not that it is incorrect, but that it makes research into retention in STEM majors seem unnecessary. In short, if what only a few researchers consider problematic is widely considered as acceptable by practitioners, then there is neither an audience nor purpose for the research.

A related problem is that, because STEM retention researchers largely disagree with the above assumption, much of the research into this area has centered on institutional reasons for switching (Strenta, et.al., 1994; Seymour & Hewitt, 1997), sometimes at the exclusion of other reasons. As mentioned in Chapter 1, neither of the data sets for these studies included lower-ability students, which lessens the effect of performance and workload in these switching decisions. In the case of Seymour and Hewitt's study, the authors chose students with a math SAT score of 650 or higher, a standard which "was chosen on the advice of STEM faculty so as to include in our sample only those students whom they expected to be able to handle the course work" (p. 25). This kind of bias is problematic for two reasons: it presumes that only certain students should major in STEM disciplines, namely those with above average math SAT

scores, and it allows researchers to ignore two important groups of students, non-switchers who persist in their major despite poor performance and switchers that leave their major due to poor performance. In addition, even though Seymour and Hewitt (1997) found that the majority of their informants chose their major based upon a lack of information and that the majority of the switchers left because they became less interested in their original major, the authors chose to concentrate on the loss of interest as a function of instruction (institution-derived) rather than as a function of an uninformed major choice (student- and institution-derived).

In addition, even the most current literature into retention and attrition in STEM majors relies on outdated data, primarily data collected up through the early 1990s. It has been over a decade since Elaine Seymour and Nancy Hewitt published the paper that ultimately became *Talking about Leaving: Why Undergraduates Leave the Sciences*, the most influential study on undergraduate attrition in the sciences to date. This book, and its predecessors, should have been the impetus for further research into this area. However, not only has there been little research since, but even the few recent studies that do exist (see Daempfle, 2003; Packard, 2005) mention the same statistics that Seymour and Hewitt (1997) reported a decade ago. Without reporting and analysis of new data sets from the past decade, there is no way to unearth the effect that this research agendum has had on the problem it studies. Has retention in the sciences improved since the 1990s, has it remained the same, or has it become worse? Similarly, has research into retention in the sciences, and the recommendations stemming from it, had an effect on the problem itself? These questions have yet to be empirically answered.

Lastly, what research that has been done has concentrated foremost on student departure from STEM majors, almost at the exclusion of student persistence in these majors. Although Astin and Astin (1993) used regression techniques to uncover what

factors were predictive of persistence, many of them speculative at best, and Seymour and Hewitt (1997) offered suggestions as to what factors help females persist, no one has adequately researched why persisters persist. This research bias is perfectly understandable because the problem is that students leave, not that they stay. However, this bias may be a reason why little research has been done in the past decade: the departure puzzle appears to have been solved. Considering that previous research demonstrates that persisters, like switchers, have plenty of reasons to leave their respective majors, and current data suggests that the attrition problem is not improving, this line of research may be crucial to our understanding of STEM departure. Understanding what enhances student persistence as well as what prevents student departure forms a more complete picture for both researchers and institutions.

Despite the above problems, the research that has been does provide an adequate context for the present study. Based upon this research, there are currently four major interrelated reasons that students switch from STEM to non-STEM majors: 1) lack of interest in science; 2) difficulties with instruction or curriculum; 3) poor performance in STEM courses; and 4) difficulties adjusting to college due to a mismatch between high school and college science teachers' expectations. These findings are from four types of studies performed concerning STEM attrition: qualitative and qualitative analysis of students' perceptions of switching decisions; regression analysis of students' performance as a determinant of switching; qualitative analysis of students' epistemological beliefs of science; and qualitative analysis of faculty evaluation of different student qualities and behaviors. Although each of these research agenda is interrelated, indicating that switching decisions probably draw upon each, very little has been done to integrate these different lines of research. The purpose of this next section is to synthesize these agenda, with one caveat: because research into retention in the

sciences is a relatively new enterprise, these three lines of research by no means represent all of the factors involved in switching.

Lack of Interest and Instructional or Curricular Factors as Factors in Switching

On the outset, interest and instructional/curricular factors appear to be separate issues. However, based upon the three studies described below, they are interrelated, with students' difficulties with instruction or the curriculum lowering their interest in the discipline. For example, Manis and colleagues (1989) found that many of their participants, more often switchers and women who did not switch, reported various negative experiences in their science courses, including poor teaching, and boring or difficult course material. These, along with competitive grading systems that did not reflect their accomplishments, caused the participants to lose interest in the discipline and confidence in their abilities. Most striking was that the authors found that participants' first-year science experiences were the most influential in their decision to switch out of their major. This follows statistical studies that show that the greatest attrition from the science during the college years occurs between the first and second year of college (Astin & Astin, 1993).

Strenta and colleagues (1994) also found similar results in their surveys. The authors surveyed over 2,500 college seniors from four highly selective undergraduate institutions, over half of whom had an initial interest in science or engineering.[13] The authors found that both science switchers and science majors reported dissatisfaction with the competitiveness, the lack of contact with faculty in and out of class, and the little motivation provided by these instructors. However, switchers (n=601) reported that they left primarily because they became attracted to other disciplines, and not necessarily due

[13] Based upon their SAT scores, high school rankings and transcripts, and college transcripts, Strenta and colleagues (1994) determined these students were, for the most part, high aptitude students.

to the climate developed in science courses. The students most often responded that they chose to leave science because another field was more interesting to them (86% of men and 90% of women) and that another field fit best with their talents (60% of men and 71% of women). Other major reasons for leaving had to do with science courses themselves: difficult material (41% of men and 48% of women), poor teaching (42% of men and 37% of women), the competitive atmosphere (38% of men and 54% of women), and too much memorization (36% of men and 37% of women). Less than one third of the students agreed with statements about the large classroom size, the inaccessibility of professors, better job opportunities in other majors, and curve-grading.

Lastly, Seymour and Hewitt (1997) identified 23 factors contributing to switching decisions that were also concerns of non-switchers, what they termed "The Problem Iceberg: Science and Mathematics Majors." (p. 47). The factors reported by more than one-third of their switchers were 1) the belief that a non-STEM major offers better education or holds more interest (44%); 2) the belief that STEM career options/rewards were not worth the effort to get the degree (40%); 3) a lack or loss of interest in STEM majors (37%); and 4) the rejection of STEM careers and associated lifestyles (34%). The factors reported by one-quarter to one-third of their informants who switched were: 5) poor teaching by STEM faculty (32%); 6) a shift to a more appealing non-STEM career option (30%); and 7) overload due to curriculum or fast pace of courses (25%).[14] These results suggest that, for the most part, switchers' reasons for leaving STEM majors centered on lack of interest in the discipline or careers connected to the discipline and difficulties with curriculum and instruction in STEM courses.

[14] The remaining 16 aspects of STEM education that concerned both switchers and persisters were reported by less than one-quarter of switchers as a factor in their switching decision. Three of these were not reported by any switchers as part of their decision.

In addition, the authors found evidence that the majority of switchers were turned off to science due to what is commonly called the "chilly climate," namely a competitive environment plagued by poor teaching, poor faculty contact and grading systems that did not adequately reflect what students felt they accomplished. Not only did nine out of ten of the switchers describe the quality of education in STEM education as poor, so did three out of four of the non-switchers. Their informants explained that the education was poor for two major reasons. First, the informants explained that STEM instructors seemed more interested in their research than teaching, seemed less supportive than instructors in other disciplines, and created a competitive, intimidating environment that discouraged participation and discussion. A side effect of poor instruction was that some of the switchers reported rejecting STEM majors and careers because of the poor role models their instructors provided. Secondly, participants were discontented about the curriculum design of many STEM majors which makes it virtually impossible to obtain a bachelor's degree in four years, thus adding to the financial strain involved in obtaining an STEM degree. Further adding to this is that some of the switchers reported they left their STEM major primarily because they did not view the rewards of an STEM degree as congruent with the amount of effort one would need to expend to complete an STEM degree.

The most important finding in Seymour and Hewitt's study is that switchers and non-switchers were remarkably similar in their behavior, concerns, and performance in their STEM courses. They found that the major difference between switchers and non-switchers is that non-switchers differed in their attitudes and the degree to which they reacted to the concerns that made switchers leave. In short, Seymour and Hewitt (1997) claimed that non-switchers had adopted "particular attitudes and coping strategies" (p.

30) that allowed them to persist in the face of the same difficulties that led switchers to leave their STEM major.

The primary limitation of each of these studies is that they exclude two groups of students that are integral to the discussion of retention in the sciences: lower-performing students who leave the sciences; and lower-performing students who persist in their STEM major despite poor performance. Although each study provides authentic evidence that institutional changes aimed at warming up the classroom would prevent some of the losses from STEM majors, because the authors controlled for academic ability, they cannot address other reasons contributing to switching, such as performance. In effect, since their studies are exclusive of realistic representations of the multiple educational backgrounds and abilities of students, these authors can make a strong case that poor instruction is a major factor in attrition from the sciences. For example, even though Seymour and Hewitt (1997) attempt to address these issues in their discussion of minority students, who they report have higher rates of switching and overall attrition, the majority of these students still came from the same group of high-ability students that made up the subject pool. This works to undermine the external validity of their results, since not all students that attend four-year institutions have similar qualifications as those in their subject pool

Performance as a Factor in Switching

Using regression analysis, Strenta and colleagues (1994) found that low grades in science courses taken during the first two years of college were salient predictors for switching. In the case of biology, these grades were a stronger predictor for switching than gender. By comparison, Seymour and Hewitt (1997) reported that only one-quarter of their switchers reported poor performance as a factor in their decision to leave a STEM major. Considering that Seymour and Hewitt relied on the subjects' self-report, which

may work to conceal embarrassment at poor performance, and because their sample drew from a considerably smaller pool of college students, Strenta and colleagues' results are very robust. Strengthening this finding is that, like Seymour and Hewitt, Strenta and colleagues drew from a population of high-ability students, meaning that, even among these students, poor performance in the first two years of college science predicted attrition. One limitation of this study was that the authors did not include performance as an item in their questions concerning students' reasons for leaving the major. Since they found it was a profound predictor of switching, it would have been interesting to see its relative importance in switchers' decisions to leave STEM majors.

High School and College Faculty Expectations as Preconditions for Switching

Related to both instructional and performance factors associated with switching decisions are lines of research into 1) differences between high school and college faculty expectations of students and 2) differences in the epistemological assumptions of switchers and non-switchers. Often treated separately, even by reviewers that make note of these issues (Daempfle, 2003), these differences are actually interrelated, feeding off of each other during the early years of undergraduate education. In effect, students who cannot or do not adapt to both the expectations and epistemological assumptions of college-level academic work will be more likely to leave.

Using ethnographic interviews and focus groups, Daempfle (2002) found that there was a well-defined mismatch between the expectations of secondary biology teachers and undergraduate biology instructors about the academic characteristics they believed were important for success in college biology. He interviewed three secondary biology teachers and four college biology instructors that were part of a "feeder unit" that started at the local high school, continued to a local community college, and ended at a local four-year university. Daempfle found that the secondary biology teachers believed

that it was important for their students to possess a working vocabulary for biology (including Latin terminology), reading comprehension, note-taking skills, and biology content knowledge. College biology instructors, on the other hand, believed that it was more important for students to have good writing skills, a good command of algebra and statistics, and the ability to integrate information from different domains, and did not find biology knowledge as important.

The most important of Daempfle's (2002) findings was that college biology teachers did not agree with any of the characteristics that the secondary teachers found important and emphasized in their teaching, primarily because the college teachers believed these were unnecessary or could be learned. For example, the college instructors believed note-taking skills were unimportant because many professors provide digests for their students, and because they preferred that students pay attention to diagrams and other material presented during lecture rather than looking down at their notebooks. Similarly, the college instructors believed that content knowledge, particularly vocabulary knowledge, was unimportant because vocabulary is easily learned, biology information changes over time, and conceptual knowledge requires integration and not necessarily memorization. Conversely, college instructors emphasized that students have good writing and math skills, neither of which were mentioned by the secondary instructors. A logical explanation for this disconnect is based upon the educational differences between high school and college biology teachers: whereas all college teachers have at least a bachelor's degree in biology, a significant portion of high school biology teachers do not. Therefore, many high school biology teachers do not have firsthand knowledge of what is expected of students as they progress through a biology degree.

Lastly, Daempfle (2002) found that the instructors differed in their epistemological conceptions of biology knowledge. The secondary instructors had an absolutist view of biology, one that emphasized facts, while the college instructors had a more tentative view of biology, one that minimized facts for a more advanced understanding of biology. Again, this is a likely result of the disparity in these teacher's educational backgrounds. This has implications with regard to the preparation of students entering college level biology. If high school biology students are being taught by instructors who have emphasized skills or concepts that are not valued by college biology instructors, then these students will have difficulty adjusting to college science.

Related to this idea is one advanced by McDade (1988), namely that students with a lower level of scientific literacy are more likely to leave the sciences. McDade (ibid.) defines this lesser scientific literacy as one that does not involve critical thinking and is "functional for passing tests and utilitarian for attaining a degree" (p. 106). In other words, the students who were studying for the grade, rather than comprehension, or taking science as a means to an end, namely a grade or as part of their degree, were more likely to leave the sciences. In this study, 29 of the 30 interviewees, all switchers from the sciences, had a view of science that was functional and utilitarian in nature. The one student who did not have this view was educated outside of the US. Although McDade does not prove that the students who remained in science did not have this same view, her study demonstrates the possibility that students' beliefs about the nature of science work against students' retention in the sciences. If students believe science is something to be memorized and not questioned, then poor teaching and a competitive climate will only decrease their interest in science.

Interestingly, Daempfle (2003) seems to separate differences in high school and college faculty expectations from students' epistemological differences, when it is likely

that one feeds into the other. Because secondary science instruction primarily relies on the memorization of facts and definitions and does not emphasize higher scientific literacy, such as integrating disciplines or evaluative or critical thinking about scientific issues, it makes perfect sense that students who adopt this view have lesser performance in college courses taught by instructors who expect these things. This does not mean that introductory college science instructors do not feed into the problem as well, by using text-heavy, didactic teaching and multiple-choice assessments. However, even college instructors that teach this way have higher expectations of their students, namely that they are independent in their learning. This too can create a disparity between what students are accustomed to and what they face their first year of science.

Taken together, the research into reasons why college students' leave the science demonstrates that a combination of a loss of interest, instructional and curricular factors, poor performance, and a disparity between the expectations of high school and college faculty are at work in causing student attrition. In effect, students arrive at their introductory biology course with a certain expectation of what they need to do to succeed, as advanced by their high school instructors, and they rely on the behaviors they used to succeed in high school biology. In a competitive academic environment, with less faculty contact, unfamiliar instructional practices, and different academic qualities expected of them, students lose interest in biology and/or perform worse than expected. All of these difficulties thus cause susceptible students to rethink not only their majors, but also their career plans.

SUMMARY

Based upon the above literature, the primary reason students reportedly chose their major, namely academic interest, was the opposite reason students reportedly left their major, namely a lack or loss of interest. This suggests two possibilities: that other

factors, including poor performance and difficulty with instruction or curriculum, weaken students' interest in their original major, or that basing one's major on academic or professional interest as developed in high school predisposes student attrition from those majors. Moreover, as Strenta and colleagues found (1994), there is also a performance factor in switching decisions, such that poor performance in the first and second years of college science was a profound component of switching decisions. However, there has not been a study of how performance plays a part of this decision, or what weight students give it in their major choices overall. The current study will address these issues as well as tell the stories of both switchers and persisters throughout their entire biology experience.

Chapter 3: Methodology

INTRODUCTION

This sequential explanatory mixed methods study combined quantitative comparison of biology switchers and persisters via a questionnaire and survival analysis; and qualitative comparison of biology switchers and persisters via semi-structured interviews and homogeneous focus groups. This chapter is divided into three major parts: a description of the source of participants; a description of both the instruments and data collection procedures; and finally a description of the data analysis techniques utilized in this study.

SOURCE OF PARTICIPANTS

The participants in this study were located using data furnished by the College of Natural Sciences at The University of Texas at Austin (College of Natural Sciences, 2006a). This data set contained freshmen who entered the biology major in the fall semesters of 2000 through 2004 and included the following information, in accordance with FERPA[15] guidelines: first semester of enrollment; enrollment status (current or not enrolled); ethnicity; gender; generation (first generation or traditional); email address; major for each semester enrolled; advising area for each semester enrolled (e.g. premed); degrees awarded; graduation status (graduated or not graduated); and number of times awarded University Honors.[16] I originally requested this data set in January of 2006 and then requested an updated version in the fall of 2006 to account for degrees awarded in May and August of 2006 for survival analysis (discussed later).

---

[15] Family Educational Rights and Privacy Act

[16] To be awarded University Honors, "a student must earn at least 45 grade points, a grade point average of at least 3.50 on courses completed in residence, and must have no incomplete grades." (College of Natural Sciences, 2007)

Participant Inclusion

To be included in this study potential participants had to be: 1) classified as freshmen in the fall semesters of 2001, 2002, 2003, or 2004; 2) classified as biology majors at the end of this first semester of enrollment; 3) enrolled during spring 2006, when questionnaires were distributed; and 4) progressing towards a degree.

The rationale for Criterion One was to include participants who were, by the number of semesters enrolled, at least in the second semester of their sophomore year (entered 2004) as well as students who had taken longer than four years to complete their degree (entered 2001). Students entering the year 2000 were not considered for selection because only a small percentage were currently enrolled, and those that were would likely graduate during the spring semester of 2006, and thus be unavailable for later participation.

The rationale for Criterion Two was to narrow the scope of participation to those with enough initial interest in the biology major to choose it prior to or during their first semester of college, and thus limit variables that would confound the data set, for example: undeclared prepharmacy students who later major in biology when they are not accepted to pharmacy school, and non-biology STEM majors who switch into biology due to difficulties with their original major. Because the data set was already delimited in this way, I did not have to exclude any participants based upon Criterion Two.

The rationale for Criterion Three was to facilitate data collection for both the questionnaire and the interviews. Based upon Criterion Three, I excluded 608 of the original 2056 students because they had already graduated or had left The University prior to graduation (transfers, dropouts, and deaths).

Finally, the rationale for Criterion Four was that someone with an undeclared major, regardless of the college of enrollment, can neither be classified as a biology

switcher nor a biology persister. Based upon Criterion Four, I excluded an additional 27 students because, although they were currently enrolled, they were classified as "Undeclared" at the time of the survey. This left a base population of n=1421 students.

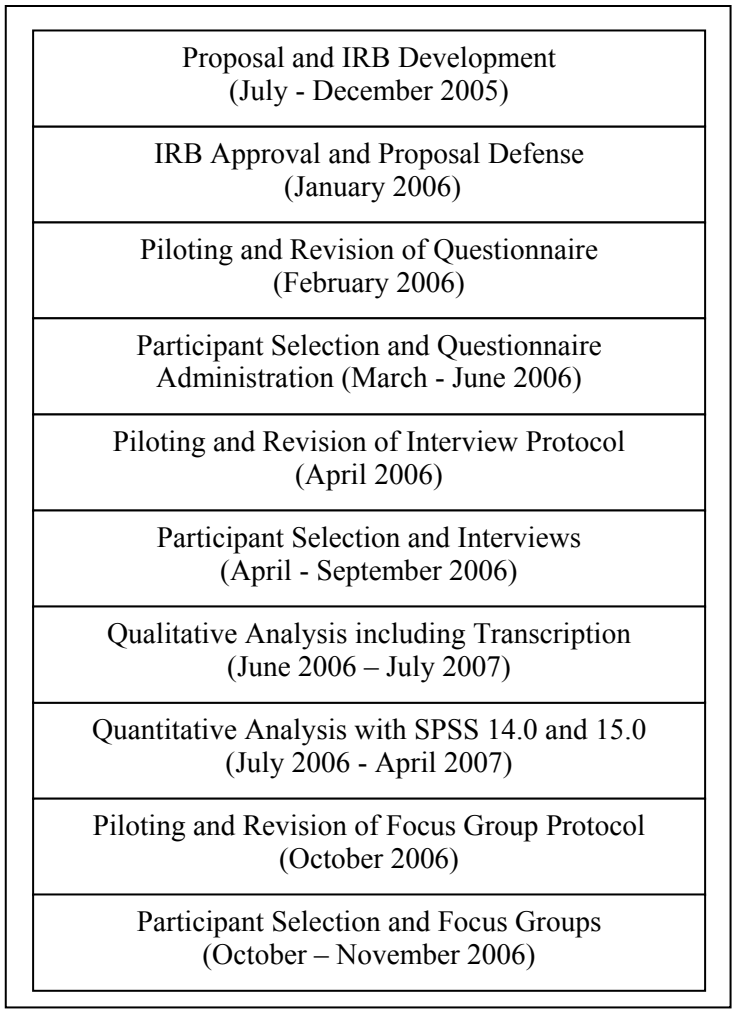
DATA COLLECTION AND INSTRUMENTATION

The current study, number 2005-12-0008, was approved by the Institutional Review Board at The University of Texas at Austin on January 11, 2006. A summary of the entire research protocol is outlined in Figure 3.1. This section of the chapter is organized based upon each of the instruments used in the study: an online questionnaire, life story interviews, and homogenous focus groups. Within each section is a description of the instrument, including its development and appropriateness; the sampling strategy used for data collection; and for the questionnaire, results of reliability and validity testing.

Questionnaire

The questionnaire (Appendix A) contains 16 demographic questions and 8 Likert-style questions about students' biology experiences, each of which is outlined in Figure 3.2. The questionnaire was developed by assimilating the findings of the studies of Maris and colleagues (1989), Seymour and Hewitt (1997), Strenta and colleagues (1994), my Master's thesis (Lang, 2004), and adding in items from my own experiences as a student and teacher in college biology.

Figure 3.1: Research Protocol



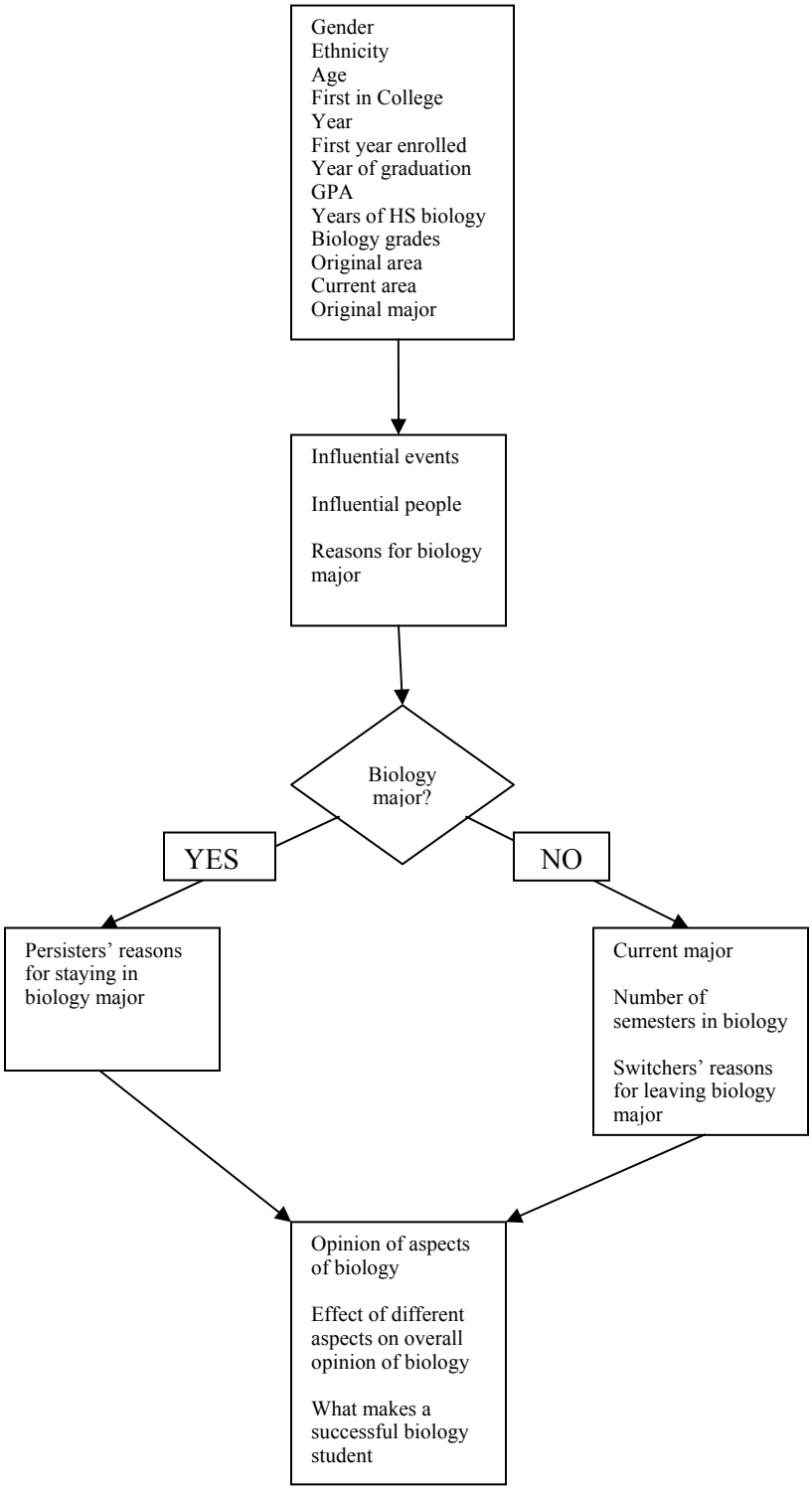
The questionnaire was programmed into Survey Monkey (http://www.surveymonkey.com) and was piloted in February 2006 to improve readability, test the skip logic, and refine the number of items included. The pilot subjects were students enrolled in an upper-division microbiology course, for which I was a teaching assistant at the time, and 111 of the students completed the survey. This course was populated primarily by sophomore and junior biology majors and undeclared

prepharmacy students.[17] I instructed the biology majors to complete the questionnaire as if they had been in the biology major since the first semester of their freshman year. I instructed the undeclared pre-pharmacy and non-biology majors complete the questionnaire as if they left the biology major for their current major. While these were not ideal pilot subjects, using these students worked out well in retrospect. Because they were never biology majors, none of the "switchers" from the pilot study were part of the real data set and thus did not contaminate the pool of switchers used in the study. This was important considering the low response rate of switchers in comparison to persisters.

I performed exploratory factor analysis to determine which items could be combined in the later questionnaire. Based upon factor analysis results and the fact that pilot participants rated these items with almost identical ratings, I combined all of the statements that asked about introductory biology and upper division biology courses into statements that asked about biology courses. This reduced the initial questionnaire by 30 items. I also removed several items from questions 19 and 20 that were not technically reasons for staying or leaving the biology and not causal and were instead statements to be agreed or disagreed with, such as "I made a bad decision when I chose to major in biology." This reduced the number of items by ten on each question. Lastly, I changed the wording on several items based upon participant comments. For example, I added prefaces to each of the items because pilot participants had difficulty keeping track of what question they were answering. Instead of the header of a question stating: "I majored in biology because" and each of the items or reasons listed below it, I changed this so that each item started with the phrase "I majored in biology because…"

[17] Biology 226T is the last course pre-prepharmacy students are required to take as a prerequisite for applying to the UT School of Pharmacy.

Figure 3.2: Outline of Questionnaire



Description of Itemized Questions and Ratings

The first three itemized questions were designed to uncover the influential precollege events or activities that helped shape the students' initial interest in biology, the people who either encouraged or discouraged this interest, and the reasons the student reportedly chose to major in biology. The rationale for asking these three questions was to clarify the evidence participants used in their decision to major in biology, whether a cognized reason or an experience that led them to the major. The items on question 15, about how different pre-college experiences influenced the participants' interest in biology, are rated on a scale from 1 (not at all important) to 5 (extremely important), and not applicable for those who did not have an experience. The purpose of this question was to uncover not only what experiences were meaningful, but also the relative importance of different experiences in terms of biology interest. The items on question 17, about how different people influenced the participants' interest in biology, are rated on a scale of -3 (greatly discouraged my interest) to +3 (greatly encouraged my interest) with 0 as a neutral score. The purpose this question was to find out which persons most encouraged and most discouraged students' interest in biology both before and during college. The items on question 19, about the reasons students actually chose to major in biology, are rated on a scale of 1 (not at all true of my experience) to 5 (completely true of my experience).

The next itemized questions (24 and 26) were ones aimed at finding out why the persisters continued in the biology major and why the switchers left the biology major. The items were originally written in the perspective of the switchers as reasons for switching (i.e. I left the biology major because…I lost interest in biology). Then the same items were reversed for the persisters (i.e. I continued in the biology major

because…I am still interested in biology). Each of these items was rated on a scale from 1 (not at all true of my experiences) to 5 (completely true of my experience).

The next itemized questions (28 through 35) were aimed at investigating participants' opinions of the biology major. These questions have identical items, but separate scales: in questions 28 through 31, participants were asked to rate different aspects of the biology major, including the teaching, advising, and courses, on a scale of 1 (poor) to 5 (excellent), results not reported; in questions 32 through 35, participants were asked to rate how each of these same aspects affected their overall opinion of biology on a scale of -3 (highly negative effect) to 3 (highly positive effect), with 0 as a neutral response. The rationale for asking both of these questions was to determine which aspects were of little and which aspects were of greater importance to positive experiences and negative experiences of biology students.

In the final question (number 36), the participants were asked to define what they think it takes to be a successful biology student on a scale of 1 (not at all important) to 5 (extremely important). Because of problems associated with this question, I excluded it from the current analysis. First, this was the last question in the survey and had not only the fewest responses, but also the most skewed data set: 175 persisters and only 45 switchers completed this portion of the survey. Second, the ratings were more correlated with length of time the participant had been in college than with their length of time in the major, so as such the results were contaminated with participants' level of academic maturity. This portion of the instrument would be more effective if it were repeatedly administered to the same group of students to see how these ideas change over time.

Appropriateness of the Questionnaire

While there are questionnaires aimed at investigating students' major and career interests, there are currently no recognized surveys designed to understand why students

choose particular majors or why they ultimately stay or leave that major. Because it was important to get a bigger picture than what interviews could provide, it was appropriate to develop a questionnaire specifically for this study. It would have been ideal if these questionnaires could be administered at appropriate time points, beginning the first year, rather than in an *ex post facto* condition. However, this was not reasonable due to the inherent time constraint and, based upon the low participation in the current study, the likelihood of drop out from a longitudinal study.

Appropriate Number of Participants

To determine the minimum number of participants required for the questionnaire, two analyses were performed: margin of error and power analysis. Margin of error analysis (5% with a 95% confidence interval) indicated that the study required 303 of the n=1421 population. Power analysis for independent samples t-tests using the average standard deviation from pilot study (σ^2=1.2) indicated that the study would have to include a minimum of 242 participants (121 persisters and 121 switchers) to achieve a power of 0.9 with a minimum effect size (D) of 0.5 and a significance criterion of α=0.05 (Eng, 2003).

Equation 3.1: $$N = \frac{4\sigma^2(Z_{crit} + Z_{pwr})^2}{D^2}$$

These sample sizes are only appropriate for use with a parametric t-test. Because the data were analyzed primarily with non-parametric statistics, particularly the Mann-Whitney comparison, I had to adjust these numbers accordingly. As explained by Gibbons and Chakraborti (2003), the Asymptotic Relative Efficiency (ARE) of the Mann-Whitney U as compared to the t-test is at worst 0.864, so to correct the sample size, one must divide the minimum t-test sample size by 0.864. This results in a sample size of 280 for a power of 0.9. Despite this lower requirement for appropriate sample

size, as compared to margin of error analysis, and due to the potential variability of the effect sizes seen in the study, I designed my sampling strategy to coincide with the sample size requirements of margin of error analysis.

Sampling Design

The initial sampling design for the questionnaire involved a systematic stratified sample of currently enrolled biology freshman entering in 2001, 2002, 2003, and 2004 (n=1421). While I initially planned to separate the switchers and persisters and choose a random sample of each, 2 x 2 chi-square analyses revealed that these test samples contained a disproportionately high number of females verses males, low number of African-American students (usually none), and a high number of non-STEM switchers versus STEM switchers. Because these were not representative of the population and contradicted the secondary purpose of the questionnaire, which was locating demographically diverse participants for the interviews, I chose to stratify the samples in two ways: 1) switchers were sorted by switching type, then by number of semesters enrolled in the biology major and 2) both switchers and persisters were sorted by gender. For example, within the switcher group, the original Microsoft Excel data file was organized as follows: non-STEM female switchers, non-STEM male switchers, STEM female switchers, and STEM male switchers and each of these groupings was organized from fewest to greatest number of semesters. I used a random number table to decide on which row to begin systematic selection and highlighted that row, then every fifth row after that until I obtained the correct sample size. To account for non-responses, I over-sampled by 50% so that there were 300 persisters and 300 switchers. Chi-square analyses of both samples demonstrated that they were statistically representative of the population in terms of gender, generation, and ethnicity.

Following participant selection in March, I emailed potential participants with the link to the questionnaire. Per IRB acceptance of a waiver of consent for the questionnaires, I did not need to have each participant sign a consent form. Due the low response rate, the disproportionately fewer responses from switchers and the fact that additional reminders were not improving participation on the questionnaire, I diverged from the initial sampling strategy in April 2006 (see Table 3.1). At that time, I sent the questionnaire to all of the persisters and switchers who had not been selected in the initial sample. Although this undoubtedly threatens the external validity of the results, the low initial sample population would have been a much greater threat.

Table 3.1: Counts of Responses from the Initial Sample and the Remaining Population

Sampling Technique	Switchers Responding	Persisters Responding	Total Responding	Total Sampled	% Response
Systematic Stratified	45	101	146	600	24.33
Remaining Population	67	106	173	821	21.07
Total	112	207	319	1421	22.45

To ensure that the final data set was representative of the parent population I used chi-square tests to compare the demographics of participants who satisfactorily completed the questionnaire to the parent data set of entering freshmen from the same years (n=2056). Table 3.2 presents the demographic description of the questionnaire participants (not including those excluded as duplicate or non-compliant).[18] In terms of gender, generation, ethnicity and persistence decision, there was no significant difference between the participant population and the parent population (gender: x^2=0.032, p=0.858; generation: x^2=1.340, p=0.247; ethnicity: x^2=0.540, p=0.910; and persistence decision: x^2=2.464, p=0.116 respectively). However, in terms of area (health professions versus

[18] Note that 369 participants actually completed the questionnaire, but 50 responses had to be deleted either because the response was a duplicate (as indicated by the originating IP address and exact duplication of responses) or the response was considered non-compliant because it contained only demographic information or it contained the same rating for each section of the questionnaire.

none/other) and initial degree sought (BA versus BS), the participant population differed. There was a disproportionately greater number of health professions students (x^2=26.365, p<0.001) and Bachelor of Science seeking students (x^2=9.601, p=0.002) in the participant population than in the parent population. It is unknown if these differences are due to sampling or due to inaccurate reporting of the participants, particularly in the case of the health professions classification, since there are students who consider themselves premed, but never officially register as premed with The University.

Table 3.2: Demographic Description of Participants Completing the Questionnaire

Factor	Value	Frequency	Percent
Gender	Male	82	37.4
	Female	237	62.8
Generation	First Generation	24	7.5
	Traditional	295	92.5
Ethnicity	African-American	20	6.3
	Asian-American	87	28.9
	Latino/Latina	55	17.2
	White	151	47.3
	Prefer not to answer	1	0.3
Year of Education	Sophomore	48	15.0
	Junior	90	28.2
	Senior	176	55.2
	Graduated/Non-Degree Seeker	3	0.9
	Graduated/Graduate Student	2	0.6
Persistence Decision	Stayed in Biology	207	64.9
	Left Biology for Other STEM Major	51	16.0
	Left Biology for Non-STEM Major	56	17.6
	Left Biology for Unknown Major	5	1.6
Initial Degree Sought	BA Biology	68	21.3
	BS Biology	240	75.2
	Undeclared Natural Sciences[19]	11	3.4
Initial Area	Health Professions[20]	214	67.1
	None/Other	105	32.9

[19] The eleven students who started college as undeclared natural sciences later declared biology as their major during the first semester of their freshman year.
[20] Health Professions includes: premedical, pre-veterinary, predental, prepharmacy, and allied health professions classifications, including those with honors.

Reliability and Validity Analysis

The reliability of the questionnaire was measured by calculating a Cronbach's Alpha score for each section of the questionnaire. This determines the reliability of each scale by measuring its internal consistency. Table 3.6 presents the summary of the reliability statistics.

Table 3.6: Cronbach's Alpha Statistics for Each Scale of the Questionnaire

Scale	Valid N	Excluded N[21]	Number of Items	Cronbach's Alpha
Precollege Experiences	109	260	26	0.867
Personal Encouragement	243	126	15	0.799
Choosing the Biology Major	319	51	38	0.839
Opinions of Aspects of the Biology Major	42	329	48	0.955
Effects of Aspects on Overall Opinion	123	246	48	0.971
Leaving the Biology Major	107	262	38	0.945
Staying in the Biology Major	190	179	38	0.936

Note that for each scale there were as many as two items that, if removed would produce the same or slightly higher Cronbach's alpha score (within 0.002 of the value presented here). Although most of these items were ones that participants tended to rate with low scores, many of them were also ones that highlighted differences between demographic groups, e.g. switchers versus persisters. Moreover, several of these items were not correlated with all of the other items in the scale (per Spearman-rho statistics, results not reported). Because the goal of questionnaire development was to produce an instrument that accounted for both major and minor variables important to groups, these items were not deleted for the purpose of analyses.

[21] List-wise deletion based on all variables. These calculations could only be completed for participants who responded to all of the items in the scale. Since not all of the participants had the same precollege or college experiences and could respond "not applicable" for those they had not experienced, the valid N for the precollege experiences, opinions of aspects of the major, and effect of aspects on overall opinion scales were lower than expected.

The validity of the questionnaire was determined using two types of evidence: content and internal structure. In terms of content validity, I used practical evidence to measure validity by evaluating comments and additional answers and determining which pilot items could be removed or combined in future editions of the survey. In terms of internal structure, I calculated an index of homogeneity for each of the scales by correlating the scores on each item with the scores on the sum of each item, or the item-total Spearman-rho[22] correlation. All but six items on the questionnaire had a statistically significant ($p<0.05$) item-total Spearman-rho correlations, indicating that, for the most part, the internal structure of each scale was sound. The item-total correlations that were not significant are detailed in Table 3.7. Note that participants tended to rate each of these items with a one or two (not at all true of me to slightly true of me), and only a few rated them with a four or five (very true of me to completely true of me), which is the likely reason for the poor correlation with the total score.

Table 3.7: Non-significant Item-total Spearman-rho Correlations (rs)

Questionnaire Item (Originating Scale)	rs	Sig. (2-tailed)	N
I majored in biology because I thought I had to choose a major in order to be admitted to The University (Choosing Biology)	-0.004	0.946	319
I left the biology major because I found out that I did not need to major in biology to prepare for or enter my chosen career (Leaving Biology)	0.126	0.196	107
I have stayed in the biology major because it would have taken too long to finish a different degree (Staying in Biology)	0.130	0.075	190
I have stayed in the biology major because it would have taken too much money to finish a different degree (Staying in Biology)	0.082	0.262	190
I have stayed in the biology major because it would have taken too much effort to finish a different degree (Staying in Biology)	0.101	0.164	190
I have stayed in the biology major because someone discouraged me from leaving the major (Staying in Biology)	0.057	0.437	190

[22] Spearman-rho was used due to the non-parametric distribution of the data.

Life Story Interviews

Utilizing the procedures and guidelines described by Atkinson (1998), I created semi-structured interview protocols designed to guide interview participants through their life story in science (see Appendices B and C). In April, I piloted the life story interviews with three graduate students (one from biology, one from nursing, and one from science education) and used their input to improve the wording of the questions on the protocol.

In late April, I began the life story interview process. To facilitate the process of storytelling, I ordered the questions in chronological order and gave the participants copies of the protocol and the consent form at least one day before the interview. For each of the interviews, I created a more detailed interview guide that included not only follow-up questions, but also questions concerning the participant's responses on the questionnaire. An example of this can be found in Appendix D. During the interview, I only asked about questionnaire items if they did not mention the same topic during the course of conversation. I paid each participant $25 and recorded each interview with both a digital recorder and a cassette tape as a backup in accordance with the IRB approval. To protect the confidentiality of the participants, the digital recordings were immediately transferred to password-protected computer, the cassette tapes were stored in a cabinet at my home, and all identifying information was removed from the transcripts.

Appropriateness of Life Story Interviews

One of the difficulties of phenomenological research is creating interview questions that simultaneously allow the participant the freedom to describe their experiences and allow you, the researcher, to find answers to specific questions. Life story interviewing satisfies both needs, providing both the story connected to the

phenomenon (breadth) and the opportunity to delve into specific areas of the story (depth) without creating artificial interviewing conditions. In addition to these benefits, for this study, the life story interview process allowed the emergence of historical commonalities among the participants. For example, many of the participants had poor or unremarkable high school physics and chemistry experiences. If I had only asked about their reasons for choosing biology without having them tell me about their high school science experiences, I may have never found out that there was a relationship between having these kinds of physics and chemistry experiences and choosing the biology major. Moreover, the use of life story interviewing is appropriate for discussions of emotionally-charged topics that are a culmination of multiple experiences, such as departure from the biology major. By virtue of its inherent chronology, life story interviewing allows the interviewer and participant the time to build rapport before questions such as these arise.

Sampling Design

This portion of the study relied on a purposive sample aimed at maximizing the diversity of participants in the life story interviews. From those participants that reported an interest in further interviews and focus groups on the questionnaire, I organized a Microsoft Excel file detailing their demographic characteristics, including gender, ethnicity, generation, major, year in school, length of time in the major, overall GPA, and biology GPA. I separated these students based upon biology GPA, with potential participants having a biology GPA higher than 3.5 to be classified as higher-performing; or lower than 3.0 or equal to 3.0 with at least one dropped biology course to be classified as lower-performing. I then selected potential participants from the higher-performing and lower-performing groups to maximize the diversity in terms of ethnicity, gender, generation, and current major. I also chose switchers who spent different numbers of

semesters in the biology major before switching and tried to limit the number who only stayed one year.[23]

Table 3.3 presents the demographic descriptions of the participants. Note that there are seven persisters and nine switchers because one of the persister participants switched her major between the time of the questionnaire and the time of the interview (the following semester). Also note that each of these participants either graduated with the major listed, or is still enrolled in the major listed as of the fall 2007 semester. Lastly, note that I contacted an additional sixteen potential participants and they either declined the request for an interview, did not respond to the request, or did not show up to the interview at the scheduled time.

Table 3.3: Demographic Description of Life Story Interview Participants

Biology Persisters				
Gender	Ethnicity	Year	Major(s)	B.P.L.[24]
Male	Asian-American	Senior	BA Biology/Premed	Higher
Male	Asian-American	Senior	BS Biology Honors/BFA Design	Higher
Male	African-American	Sophomore	BS Human Biology/Premed	Higher
Female	Latina	Junior	BA Biology/Premed	Higher
Female	African-American	Junior	BA Biology/BA Linguistics/Premed	Lower
Female	Latina	Junior	BA Biology/BS Clinical Lab Science	Lower
Female	Asian-American	Sophomore	BS Neurobiology/Premed	Lower
Biology Switchers				
Gender	Ethnicity	Year	Major(s)	B.P.L.
Male	White	Junior	BA Government	Lower
Male	Asian-American	Senior	BBA Accounting/Premed	Higher
Male	White	Junior	BS Chemical Engineering/Premed	Higher
Female	White	Junior	BA English	Lower
Female	Latina	Junior	BA Psychology	Lower
Female	African-American	Senior	BS Human Development/Premed	Lower
Female	Asian-American	Sophomore	BS Psychology	Lower
Female	White	Junior	BS Nursing (BSN)	Higher
Female	White	Senior	BS Nursing (BSN)	Higher

[23] One spent a single semester in the biology major, one spent two semesters in the biology major, four spent three semesters in the biology major; two spent four semesters in the biology major; and one spent seven semesters in the biology major.

[24] B.P.L. is the Biology Performance Level

Focus Groups

Utilizing the procedures and guidelines outlined by Litoselliti (2003) and Puchta and Potter (2004), I created focus group interview protocols designed to allow homogeneous groups of persisters and switchers to discuss their experiences as a biology student, their reasons for choosing and their reasons for either staying or leaving the biology major (see Appendices E and F). In October 2006, I piloted the focus group interview with three graduate biology students. Based upon the pilot results, I removed several questions from the protocol and added a question asking students to describe their motivation for choosing the biology major.

In November 2006, I began the focus group process. After explaining the ground rules and having participants sign the consent forms, I began focus group with an introductory question, designed to both promote discussion and allow participants to air grievances about their experiences in the beginning of the interview. For this and the more salient questions, I had the participants jot down their ideas onto large index cards and tape them to the wall. This simultaneously allowed participants to see, discuss, and ask questions about others' ideas, and more importantly, gave them an appropriate amount of think-time when answering the questions. In addition, because I asked each person to explain what they had written on their cards, the use of these cards removed them from a potentially passive role of an answerer of questions, into the more active role of a presenter of ideas. Lastly, the use of the index cards created a natural order to the interview by minimizing the likelihood of participants talking over each other. Instead, each participant talked in turn, which allowed them to complete their thoughts and the other participants to listen and respond. I recorded the focus groups in the same manner as I had with life story interviews. I paid each participant $10 and provided pizza and

beverages. I also took digital photographs of the index cards at the conclusion of each focus group to ensure accuracy of data collection and organization.

Appropriateness of Focus Groups

The primary rationale for using focus groups was to improve the efficiency of qualitative data collection for the study. Second, since the life story interview participants were purposely selected to obtain the breadth of experiences of biology students, it was also important to fill in any gaps between these individuals, particularly in terms of their reasons for choosing and either leaving or staying in the biology major. Rather than simply conduct a series of shorter interviews, I also thought it was necessary to focus on the bigger questions, particularly the commonalities and differences among the groups of switchers and persisters, and to hear these groups discuss of their experiences.

Sampling Design

This portion of the study relied on purposive sampling based upon current major and convenience sampling based upon potential participants' ability to meet at prescheduled focus groups. Because most of the persister life story participants were classified as premed, I attempted to balance this out by specifically choosing focus group participants who were not premed, and verifying this upon initial contact. I had used all eligible switcher volunteers for the life story interviews, so I elected to email currently-enrolled switchers using the Registrar data. Because so few were interested in participating in focus groups (many ignored the email), I had to cancel one of the switcher groups. This resulted in four persister focus groups and three switcher focus groups. In addition, even though four to five participants agreed to attend each focus

group, ten individuals did not show up to their assigned group, resulting in some focus pairs rather than groups.

Table 3.5 presents the demographic description of the focus group participants. Note that the truancy and reluctance of focus group volunteers as well as the cancellation of the final switcher focus group severely skewed the numbers of switchers and persisters involved in this part of the study.

Table 3.5: Demographic Descriptions of Focus Group Participants

Biology Persisters			
Gender	Ethnicity	Class	Major
Male	Asian-American	Junior	BA Biology/Premed
Male	White	Senior	BS Ecology, Evolution, Behavior
Male	Latino	Senior	BS Human Biology
Male	Asian-American	Senior	BS Neurobiology
Female	White	Senior	BA Biology
Female	Asian-American	Junior	BA Biology/Premed
Female	White	Senior	BA Biology/Premed
Female	Asian-American	Senior	BS Cell and Molecular Biology/BA Plan II[25]
Female	White	Senior	BS Human Biology
Female	White	Senior	BS Human Biology
Female	White	Junior	BS Microbiology
Female	White	Senior	BS Neurobiology
Biology Switchers			
Gender	Ethnicity	Class	Major
Male	White	Junior	BA Linguistics
Male	White	Senior	BA Plan II/BA Government
Male	Asian-American	Senior	BS Radio, Television, Film
Female	White	Junior	BS Advertising
Female	African-American	Junior	BA Government
Female	White	Senior	BA Human Ecology
Female	White	Senior	BS Plan II

25 The Plan II Honors Program is a multi-disciplinary liberal arts degree program in which students "explore the humanities, the natural sciences, and the social science" rather than concentrate on a single discipline. (Bauermeister, et.al., 2006)

DATA ANALYSIS PROCEDURES

This next section is divided into four parts: the procedures used to recode the data set used to locate subjects; the procedures used for quantitative data analysis; the procedures used for qualitative data analysis; and the procedures used for mixed-methods legitimation.

Manipulation and Organization of Registrar Data

Because the raw data supplied by the College of Natural Sciences contained the official codes designated for each college and major for each semester enrolled, the first task was to use these codes to determine 1) what each student's major was for each semester enrolled; 2) their initial degree sought (BA versus BS); 3) how long they stayed in the biology major; and 4) their current status, whether biology major, STEM switcher, non-STEM switcher or dropout. What follows is a description of the procedure I used to translate these codes in these four ways.

First, I translated each of the major codes for each student into a more reasonable number. The official code consists of three parts: a college code, a major code, and an advising code. For example, for E14614, E means the College of Natural Sciences, 146__ means BS Human Biology, and 14 means Premedical, Predental, Preveterinary (Office of the Registrar, 2005). Using this example, I translated the code E14614 into four codes, and thus four columns on the Excel spreadsheet: 1 for College of Natural Sciences; 2 for Bachelor of Science; 3 for Human Biology; and 1 for Health Professions. Similarly, I translated a student with the code E14400 into: 1 for College of Natural Sciences; 1 for Bachelor of Arts; 1 for Biology; and 0 for None/Other. Because of the variety of advising area codes and the comparatively low number of non-health professions advising codes in the population (i.e. pre-law), I divided them into two areas only: health professions and none/other. I created major codes and advising codes for

each student for each semester enrolled. Secondly, using these tracking codes, I counted the number of semesters each student was enrolled in the biology major. Finally, I looked at the degree earned or current semester of enrollment (for currently enrolled students) to determine the status of the student. I coded biology persisters and graduates with a 1, STEM switchers with a 2, non-STEM switchers with a 3, dropouts, transfers, and deaths with a 4, and undeclared students with a 5.

To verify the coding, I checked all codes against the degree earned and I randomly selected several currently enrolled students and searched for them on the directory using their email address. I found two minor problems with the coding, both of which were connected to double-majoring in biology and another discipline. First, since the registrar data only included one major code, the addition of a second major sometimes appeared as the change to a new major. I found eight instances of this and all were biology students who added a second major prior to graduation. There were likely others like this among the currently-enrolled students, but I could not reconcile them without knowing their final degree attained. Since there were only eight of these among the pool of graduated students, it is unlikely that this was a salient error overall. Second, there were other biology students double-majoring who earned the other degree prior to their biology degree. These were initially coded using the non-science degree they earned, but had to be recoded as biology majors based upon the current semester of enrollment which indicated they were earning a biology degree. All 25 of these could be easily reconciled using the current semester major and the degree attained.

Quantitative Analysis Procedures

All data analysis was performed using SPSS 14.0 (during 2006) and SPSS 15.0 (during 2007). Due to the non-normal distributions of all but one set of data, which

violates a major assumption of both the t-test and ANOVA, I used non-parametric statistical analyses unless otherwise specified.

Registrar Data

1. To perform demographic analysis on the biology students entering in the falls of 2000 through 2002, I created frequency tables for the different demographic groups. All 1654 students were included in the majority of analyses. Exceptions are noted in the results.
2. To perform demographic analysis on the biology graduates from academic years 2003 through 2006 and the biology freshmen entering in the fall semesters of 2000 through 2002, I created frequency tables for the different demographic groups. For the former, I limited the data set to include only students who entered The University as freshmen. The original data set contained 1788 students, and I excluded 399 because they were classified as transfers. All 1389 of the remaining students were used in the analyses.
3. To find out if there would be any residual effects among demographic variables, indicating a possible interaction between variables, I compared the counts of the different demographic categories using the Chi-square test of independence available through the Cross-Tabs function.
4. To determine the overall survival of biology students, I performed Life Table Analysis on the fall 2000 through fall 2002 data set, with number of semesters in the biology major as the time variable. Students who left the major were coded as 1 (not surviving) and students who stayed in the major were coded as 0 (surviving). I repeated this procedure for comparisons of students who left biology for other STEM majors (STEM switchers) and those who left biology for non-STEM majors (non-STEM switchers).

5. To compare the survival rates of different demographic groups (X and Y), I performed Kaplan-Meier comparisons using the same data set. For statistically significant differences between or among groups, I also performed Kaplan-Meier comparisons on the component data sets to determine the source of this difference. To do this I created dichotomous combination variables, such as 1 for white female and 2 for white male.

6. To calculate the effect size associated with the Kaplan-Meier comparisons, I calculated an odds ratio using the following equation (Bland & Altman, 2000):

Equation 3.2: Odds Ratio (OR) = $\frac{A/B}{C/D}$ or $\frac{AD}{CB}$

Where: A = the number of group X staying
B = the number of group X leaving
C = the number of group Y staying
D = the number of group Y leaving

The 95% confidence interval of the odds ratio is based upon the following calculation (ibid.):

Equation 3.3: $e^{\ln(OR)\pm 1.960x(SE_{\ln(OR)})}$

Where: $SE_{\ln(OR)}=\sqrt{(1/A+1/B+1/C+1/D)}$

Salient results are ones in which the Hazard Ratio is greater than one and the lower limit of the 95% Confidence Interval does not fall below one.

7. To determine which entry demographic characteristics were most associated with switching, I performed forward step-wise Cox regression (likelihood ratio) using the same data set. For this, I loaded the following variables: gender (male/female), generation (first/traditional), ethnicity (African-American/Asian-American/Latino/White, initial degree sought (BA/BS), and initial advising area (health professions/none or other).

Questionnaire Data

1. To determine whether questionnaire responses violated the assumption of normality required for a t-test, I performed Kolmogorov-Smirnov tests for normality for each scale of the questionnaire, as well as any sums of the scales.
2. For non-normally distributed data, to determine whether the questionnaire responses of switchers and persisters have the same distribution, I used the Mann-Whitney U test if the N for each group was 25 or higher and the Kolmogorov-Smirnov Z test if the N for one or both groups was below 25 (Field, 2005). I repeated this procedure for comparisons of STEM-switchers and non-STEM switchers. I performed Bonferroni corrections for each set of questionnaire responses by dividing the p-value threshold 0.05 by the number of tests (Abdi, 2007). To balance the possibility that these corrections increased Type II error, significant results were still reported at the $p<0.05$ with footnotes describing which results exceeded the Bonferroni-corrected p-value threshold.
3. To calculate an effect size (r) associated with the Mann-Whitney U test, I used the Z-score calculated from the Mann-Whitney U score in the following equation (Field, 2005):

   Equation 3.4: $r = \frac{|z|}{\sqrt{N}}$

   Note that this value of r is evaluated in the same way as the correlation r, with a significant effect size being equal to or greater than 0.3.
4. For normally-distributed data, to determine if the mean ratings of switchers and persisters were the same, I used the independent samples t-test, with a Levene's

test for equality of variances and automatic Welch's t-test correction in case the homogeneity of variance assumption was violated.

5. To calculate the positive and negative total scores for rating scale with a middle rating of zero, such as -3 greatly discouraged to +3 greatly encouraged, I calculated the sum of the products of each rating and the proportion that chose the rating, as follows:

   Equation 3.5: Encouragement Score = $1(prop_1) + 2(prop_2) + 3(prop_3)$

   Equation 3.6: Discouragement Score = $-1(prop_1) - 2(prop_2) - 3(prop_3)$

   I then added these scores together to get a total score.

6. To calculate the total score for rating scales above zero, such as 1 not at all true of me to 5 completely true of me, I followed the same procedure as above, but only used ratings of three or higher in the calculation so that the resulting total would contain only items deemed as important.

   Equation 3.7: Total Score = $3(prop_3) + 4(prop_4) + 5(prop_5)$

7. To determine the reliability of each scale on the questionnaire, I used the alpha model under the Reliability Analysis function (results reported earlier). To determine the validity of each scale, I added up each of the scores and performed non-parametric correlation (Spearman-rho) comparing each item with its total (results reported earlier).

8. To determine possible associations between biology grades and participants' reasons for staying in or leaving the biology major, I first calculated a summary biology grade for each participant based upon grade calculations at The University. I then performed Spearman-rho non-parametric correlation analysis comparing biology grades and the reasons switchers left the major, as well as biology grades and the reasons persisters left the biology major.

Qualitative Analysis Procedures

Transcription

I began transcribing both interviews and focus groups in the order they were scheduled. During transcription, I removed all identifying information and encoded each participant's responses with an alphanumeric code for tracking purposes. Following both the transcription of the interviews and focus groups, I rechecked the transcript against the recording, made any necessary corrections, added additional discourse markers, and added any nonverbal cues such as head-nodding that I had recorded in my notes. For the life story interviews, I sent the completed transcript to each participant, along with a form to indicate any corrections or additions they wanted to make (Appendix G). For the focus group interviews, I compared each transcript against the note cards to verify accuracy of the transcript and the originating voices.

Coding Procedure

To improve the legitimacy of the coding procedure, I continually zoomed in and zoomed out of the data set, using a combination of qualitative coding methods: the Constant Comparative Method (Dye, et.al., 2000; Lincoln & Guba, 1985) and the deductive coding methods outlined by Patton (2002). Due to the volume of data,[26] I first categorized the interview and focus group data by the larger question asked. For example, all explanations for why students chose to major in biology were categorized into a theme labeled "choosing biology." From these themes, I began removing quotes from the Microsoft Word document for that theme and starting a new document for each sub-theme. Following the Constant Comparison Method, as I contemplated adding each new quote to a sub-theme, I compared it to each of the other quotes that were part of that

[26] Persister interviews and focus groups contained 153,131 words and switcher interviews and focus groups contained 165,836 words, for a total of 318,967 words.

sub-theme and reasoned through its inclusion or the initiation of a new sub-theme. At the same time, I reasoned why the other quotes should stay in light of the addition of this new quote. In some cases a quote could be categorized into more than one sub-theme. To reconcile these, I removed all of these quotes to a separate document and noted which sub-themes were potentially presented. After finishing the rest of the coding, I followed the procedure below:

1. If the quote was divisible and its component parts made sense in terms of both content and context, I divided the quote and coded each part separately
2. If the quote could not be divided without destroying its meaning, I went back to the originating transcript, reread the text surrounding the quote and categorized it based upon its context alone.
3. In a few cases, I re-edited the quote by including the prefacing words so that it could be properly divide (if necessary) and categorized.

I was able to categorize each of these types of quotes using this procedure.

Once I completed initial coding in this manner, I refined the codes using deductive coding methods of analyzing for convergence and analyzing for divergence (Patton, 2002). Analyzing for convergence involves determining, for each sub-theme, the internal homogeneity (or "the extent to which the data that belong in a certain category hold together or 'dovetail' in a meaningful way" and the external homogeneity (or "the extent to which differences among categories are bold and clear" (p. 465). I evaluated the internal homogeneity for each of the sub-themes by reading through each sub-theme, making sure that each of the quotes described the sub-themes and, when applicable, dividing sub-themes into infra-themes. I evaluated the external homogeneity by making sure that sub-themes were distinct, joining any that upon further analysis were truly infra-themes under the same sub-theme. I analyzing for divergence by looking for natural

associations between themes, what Patton (2002) terms "bridging." Because much of the data was in chronological time periods, from childhood through college, I mapped out connections between logical data chunks, such as high school science experiences to choosing biology as a major. I concluded the coding process when all quotes were categorized. The list of final codes is located in Appendix H.

Effect Size Calculations

To determine the relative importance of the sub-themes emerging from interviews and focus groups, I elected to calculate frequency effect sizes (Onwuegbuzie, 2001; Onwuegbuzie & Teddlie, 2003)), rather than rely on the commonly-used and vague adjectives: few, many, and several. For each sub-theme, I counted the number of individuals who contributed to that sub-theme and divided that by the total number of individuals contributing to the theme. I calculated separate frequency effect sizes for switchers and persisters, to highlight similarities and differences between the groups. I elected to use simple frequencies rather than word counts to compare the importance of the sub-themes because of differences in the loquaciousness of participants and the greater number of words uttered per person in the life story interviews versus the focus groups.

Legitimation Procedures

Using the typology compiled by Onwuegbuzie and Leech (2007), I used several methods to legitimate the qualitative data. Below is a listing of each method I utilized in the current study and a description of how it helped legitimate the data, whether in terms of data collection, presentation, or analysis.

1. *Prolonged engagement.* The life story participants received the questions prior to the interview to give them sufficient opportunity to think about their answers;

both the life story and focus group interviews were designed to allow sufficient time to build rapport with the participant; focus group participants were given sufficient amounts of think-time during the interviews with the use of note cards.

2. *Triangulation*. The research design relied primarily upon triangulation of data, as well as methodologies, since it is a mixed-methods study. Each data set is intentionally complementary to the others, with the questionnaire providing the larger picture that is not possible with life story interviews or even several focus groups, the life story interviews providing the depth not possible with the questionnaire or focus groups, and the focus groups both filling in gaps left by the interviews and providing additional support to the larger themes emerging from the interviews.

3. *Leaving an audit trail.* I have extensive documentation for all parts of the study, from the proposal stage, through data collection and analysis, and integration of data sets.

4. *Member checking/informant feedback.* Life story interview participants checked their transcripts for accuracy. Because many of the participants have graduated since the study began, it was not reasonable to have them check categories and interpretations derived from the data. To alleviate this, as much as possible, I have used the participants' words to explain phenomenon rather than my own. This improves the interpretive validity (Maxwell, 1992) of the emergent themes.

5. *Checking for researcher effects/clarifying researcher bias.* To minimize my effect on the participants, I rarely deviated from the interview protocol, leaving additional explanations participants requested (i.e., such as my feelings about people leaving the biology major), for the end of the interview, after recording stopped. The interviews were conducted in a neutral site and I was very clear

about my intentions with regards to this research, as well as their part in it (i.e. that the purpose of the focus group was not to reach a consensus).

6. *Making contrast/comparisons.* Although this study technically has no control group, the act of comparing switchers and persisters with respect to their experiences not only highlights differences in each, but also improves the descriptive value of the data presented.
7. *Ruling out spurious relations*. In cases in which a possible causal link emerged, I investigated possible moderating variables and made note of any relationships that were associations or correlations, rather than causations.
8. *Referential adequacy.* Each of the life story and focus group interviews were recorded and photographs were taken of the focus group note cards for data comparison.
9. *Rich and thick description.* Each of the recordings of life story and focus group interviews were transcribed and notes were taken during the focus groups.
10. *Effect sizes.* As mentioned earlier, I calculated the frequency effect sizes for sub-themes to not only improve data comparison, but ensure that I did not inflate the importance of less substantial findings.

SUMMARY

This chapter laid out the research protocol, including the source of participants, data collection and instrumentation, and data analysis procedures. Each of the instruments can be found in the Appendices A through G; and the list of codes can be found in Appendix H. The next chapter presents both quantitative and qualitative results in chronological order of time period from participants' precollege experiences through their persistence or departure decision.

Chapter 4: Results

For purposes of clarity, I have organized the results not by the source of data, as described in Chapter Three, but primarily by chronological time periods: Precollege Experiences; Choosing Biology; Experiences in and Perceptions of the Biology Major; The Phenomenon of Staying; The Phenomenon of Leaving; and The Role of Performance on Persistence. Within each of these major divisions, I have described the sources of data in the introductory paragraph and organized the data by presenting relevant quantitative data and then relevant qualitative data in separate sections. The research questions guiding the results chapter were:

1. How do biology persisters and switchers compare in terms of:
   - Demographic characteristics?
   - Precollege experiences with science?
   - Sources of encouragement with regards to biology?
   - Their decision process with regards to major choice?
   - Their experiences in and perceptions of the biology major?
   - The role that performance plays with regards to their persistence or departure?
2. Why do biology persisters stay in the biology major?
3. Why do biology switchers leave the biology major?

PRECOLLEGE EXPERIENCES AND SOURCES OF PERSONAL ENCOURAGEMENT

To understand and compare switchers' and persisters' experiences prior to college enrollment, as part of the questionnaire, participants rated the importance of various precollege experiences in terms of developing their interest in biology, as well as whether various people encouraged or discouraged their interest in biology. In life story interviews, participants expanded upon these responses. The next section presents results from both the questionnaire and life story interviews: the quantitative then qualitative

results concerning precollege experiences; and the quantitative then qualitative results concerning precollege persons.

Precollege Experiences: Quantitative Results

Tables 4.1 and 4.2 present the precollege experiences most important in developing persisters' and switchers' interest in biology, respectively. The top five experiences in each group were identical; and most of the responses were repeated between groups. For both, enjoyment of and performance in high school biology were the most important in developing their interest in biology.

Table 4.1: Top Precollege Experiences Persisters Rated as Important in Developing Their Interest in Biology (proportion > 0.50; in descending score order).

Precollege Experiences (3 Moderately Important to Extremely Important 5)	N	M	Score	Prop.
Enjoyment of High School Biology	204	4	3.82	0.88
Performance in High School Biology	204	4	3.58	0.86
Educational TV	204	4	3.15	0.79
Working with Patients	171	4	2.96	0.72
Enjoyment of Middle School Science	204	3	2.81	0.70
Field and Laboratory Experiences	170	3	2.64	0.67
Science Museums	193	3	2.62	0.67
Performance in Middle School Science	207	3	2.57	0.65
Person of Significance with HP Career	137	3	2.35	0.56
Reading Journals and Non-Fiction	187	3	2.34	0.62
Having a Relative or Friend with Illness	156	3	2.26	0.56
Summer Programs/Internships	114	3	2.24	0.54
Prime Time TV	196	3	2.14	0.57
Zoos, Botanical Gardens, Marine Parks	193	3	2.06	0.54
Reading Sci-Fi	183	3	2.03	0.55
Direct Experiences with Nature	190	3	1.98	0.51

Table 4.2: Top Precollege Experiences Switchers Rated as Important in Developing Their Interest in Biology (proportion > 0.50; in descending score order).

Precollege Experiences (3 Moderately Important to Extremely Important 5)	N	M	Total Score	Prop.
Enjoyment of High School Biology	111	4	3.65	0.87
Performance in High School Biology	112	4	3.51	0.86
Educational TV	104	3	2.96	0.76
Working with Patients	88	3	2.82	0.68
Enjoyment of Middle School Science	107	3	2.68	0.72
Performance in Middle School Science	107	3	2.64	0.71
Person of Significance with HP Career	85	3	2.62	0.65
Field and Laboratory Experiences	101	3	2.46	0.63
Having a Relative or Friend with Illness	81	3	2.41	0.63
Prime Time TV	108	3	2.30	0.61
Summer Programs/Internships	68	3	2.21	0.56
Science Museums	103	3	2.05	0.57
Being a Patient	95	3	1.98	0.54
Direct Experiences with Nature	103	3	1.96	0.54
Reading Journals and Non-Fiction	101	3	1.89	0.54

Mann-Whitney comparison of the importance of switchers' and persisters' precollege experiences revealed tremendous similarity (Table 4.3), with these groups only differing on three items, none of which were particularly salient based upon the effect sizes, Bonferroni-corrected p-value, and relative placement on Tables 4.1 and 4.2.

Table 4.3: Comparison of Persisters' (P) and Switchers' (S) Precollege Experiences ($p<0.05$; in descending effect size order).

Precollege Experiences (1 Not at all Important to Extremely Important 5)	N	M (P)	N (P)	M (S)	N (S)	U	Z	Sig. (2-tailed)	Effect Size r
Science Museums (P>S)	296	3	193	3	103	8004	-2.827	0.005[§]	0.164
Reading Journals/Non-Fiction (P>S)	288	3	187	3	101	7978	-2.227	0.026[§]	0.131
Zoos, Botanical Gardens, Marine Parks	295	3	193	2	102	8327	-2.238	0.025[§]	0.130

[§] Exceeds Bonferroni-corrected p-value of 0.0019

To address the possibility that it was not the types of precollege experiences, but rather the number or overall importance of these experiences, I also compared switchers

and persisters in terms of total number of and total score for their college experiences. Tables 4.4 and Table 4.5 demonstrate that there was no significant difference in the number or the importance between switchers' and persisters' precollege experiences. Note that the t-test was used for to calculate this difference because the Kolmogorov-Smirnov Test for Normality showed these scores were normally distributed (0.041, df=319, p=0.200).

Table 4.4: Comparison of the Number of Persisters' (P) and Switchers' (S) Precollege Experiences

	N	M (P)	N (P)	M (S)	N (S)	U	Z	Sig. (2-tailed)
Number of Precollege Experiences	319	21	207	22	112	10906	-0.891	0.373

Table 4.5: Comparison of the Total Importance of Persisters' and Switchers' Precollege Experiences (using sum of ratings of experiences)

	N	Mean	SD	t	df	Sig. (1-tailed)
Persisters	207	59.39	15.917	0.849	317	0.198
Switchers	112	57.73	17.935			

Levine's Test for Equality of Variances (F = 1.645, p=0.201)

Altogether these results imply that, whether they eventually stayed or left the major, freshmen arrive at the biology major with basically the same suite of experiences and that these experiences have little to do with their eventual persistence in the major.

Precollege Experiences: Qualitative Results

Because life story interview participants had such varied backgrounds, they also tended to have varied precollege experiences which helped develop their interest in biology. Despite this, there were noticeable trends with regards to their earliest memories of science as well as importance of a variety of formal and informal experiences later in childhood or adolescence. This next section begins with participants' first memories of

science, a description of the most common precollege experiences they experienced, and lastly a description of the effects of high school science experiences on participants' interest in biology.

First Memories of Science

To both help relax and orient the life story participants, I began each interview asking them to tell me about their first memories of science. While not planning to use these for data analysis, I quickly noticed that two general types of memories emerged: family-centered memories and school-centered memories. The typical family-centered memory involved parents or other family members teaching scientific principles, as one persister described: "I guess my first memory would be my mom taking an orange and a flashlight and demonstrating the planets, just the rotation of the planets, in the bathroom [when I was three or four]." Other family-centered memories involved parents helping their children with their science fair projects, as described by a switcher:

> It was my first science fair. It was in kindergarten and my dad and I---it was the first time we really did something together 'cause he had just adopted me---and so we took plants and tried to see what types of water or colors helped them grow better…It was a really positive experience, just being able to interact with someone new and…he actually ended up…helping me with science fair every year for 13 years. So, it was just a good way to jump into science.

As in the above example, these early family-centered science experiences typically served as a foundation for a relationship with the family member, and science became an integral part of that relationship, as another persister explained:

> …my grandpa on my mom's side is a geologist and…he got me started on a rock collection and would show me different rocks, or take me to the bayou by his house and show me animals and like teach me how to make bubbles and stuff like that. He really liked to teach me how to experiment and explore…

Contrasting these is that the typical school-centered memory involved liking experiments or demonstrations from science class or a particular teacher, and not forging

a long-term relationship with either science or a particular person. Moreover, while family-centered memories took place before kindergarten, as early as age two, school-centered memories came from later childhood, from elementary and as late as middle school. For example, the following was described by another switcher:

> I think the first time I remember science was in 5th grade, where we did those like tornado things in the two 2-liter soda bottles and you put them together and you swirl it around. I go, "Wow, that's really cool." And we did the volcano, put the baking soda in it and put the vinegar in it and it exploded. That really just set of kind of like, "This is really cool. I really like it."

Another, though rarer[27] kind of school-centered memory involved liking a particular teacher, as another switcher described: "The first time I really remember science was 3rd grade. I had a teacher named Mrs. _____ and she was a nice lady, you know? And so everybody liked her and that's the first time I ever really remember liking science, you know?"

Although both switchers and persisters reported family-centered and school-centered memories as their first memory, there was a noticeable trend in which persisters were far more likely to describe family-centered memories than school-centered memories, whereas switchers were equally-likely to describe both (Table 4.6). There was no association between a participant reporting family-centered memories and having college educated parents in this case and there were very few differences between first generation and traditional college students overall.[28]

Table 4.6: First Memories versus Persistence Decision

	Switchers	Persisters
Family-Centered	4	6
School-Centered	5	1

[27] Two of the participants had teacher-centered school memories.

[28] For example, the quantitative results comparing first generation and traditional college students with respect to precollege experiences indicated they differed significantly in only one aspect: traditional college students were more likely to report the importance of a significant adult working in the health professions than first generation college students ($Z=-2.149$, $p=0.032$, $r=0.144$).

Important Precollege Experiences

As presented in Table 4.7 and echoing the quantitative results, life story interview participants overwhelmingly described their high school biology experiences as the most important in developing their interest in biology, often adding that these experiences played a role in their decision to major in biology (as described later). Furthermore, switchers and persisters were very similar in terms of the other experiences that helped develop their interest in biology. Exemplary quotes describing these other experiences can be found at the conclusion of this section, in Table 4.9.

Table 4.7: Precollege Experiences Persister and Switcher Participants Reported as Important in Developing their Interest in Biology (in descending order of frequency effect size)

Persister Precollege Experiences (N=7)	Persister Frequency Effect Size	Switcher Precollege Experiences (N=9)	Switcher Frequency Effect Size
High School Biology	1.000	High School Biology	1.000
Educational Television	0.429	Educational Television	0.556
Science Fair Participation	0.429	Science Fair Participation	0.556
Informal Science Experience	0.429	Informal Science Experience	0.333
Family Member with Illness	0.429	Being a Patient	0.333
Reading about Science	0.286	Reading about Science	0.333
Health Profession Internships	0.286	Health Profession Internships	0.222
Being a Patient	0.143	Family Member with Illness	0.111

All of the participants described a high school biology or anatomy course as the primary or secondary reason they were interested in biology. For example, like several of the participants, one persister described her freshman biology course, particularly her lab, as the best experience she had in high school.

> …in 10th grade, I took biology with Mr. _____ who was a really cool teacher. I loved that class, everything about it. It was just like that biology textbook I got [when I was younger] and I was excited, I was like, "Yah!" And we had these fun labs and one of them was electrophoresis and another one was splicing with bacteria and viruses, and I was just, "Aah!"…That was definitely the best part of high school science. And the labs, the electrophoresis lab was like, the cream of

> everything. It was so awesome 'cause I was really into DNA and so I was like, "Yessss! This is amazing." That was the best part of high school right there.

Like the above, many of the stories about enjoying high school biology centered on hands-on experiences, especially dissection. Whether these dissections occurred as part of their freshman biology course or a senior anatomy and physiology course, all of these participants described dissection as important in helping them learn biology, as one persister described:

> We'd learn a section, like we'd learn a major system in anatomy and then we'd really focus on that on the dissection, when that came up. Like when we learned about eye tissue, eyesight, we dissected a sheep's eye. And so, once you've learned it, you didn't really forget about it 'cause you went and actually applied what you learned afterwards and that was pretty cool.

Overall, and as indicated in Table 4.8, both persisters and switchers had positive experiences in their first biology course. The participants who had negative freshman biology experiences either had positive experiences in Anatomy and Physiology or Biology II, which made up for the first experience, or had poorer or otherwise unremarkable experiences in other science courses, which made biology look more appealing in retrospect.

Table 4.8: Introductory HS Experiences of Life Story Interview Participants (N=16)

Course	N (P)	Count	Persister Frequency Effect Size	N (S)	Count	Switcher Frequency Effect Size
Positive Biology I Experience	7	5	0.714	9	8	0.889
Positive Chemistry I Experience	7	2	0.286	9	2	0.222
Positive Physics I Experience	7	2	0.286	7*	2	0.286

* Two switchers did not take physics

Conversely and also indicated in Table 4.8, in terms of their non-biology science experiences, most persisters and switchers had negative or unremarkable, almost opposite, experiences in high school chemistry and physics. A negative experience meant that the participant described the course as a reason they did not or do not like the

discipline as a whole ("I did not like physics at all and I think because of that class, it made me not like physics here."); whereas an unremarkable experience meant that the participant described the course as boring or of no educational value ("Oh yeah, I kinda disliked that class, not 'cause of the material. I liked the material, but it was…at the end of the day…[and] the teacher was really boring, yeah.") These two descriptions were combined in analysis because, as seen in a later section of the results, these opinions, whether of dislike or indifference, affected students' choice of college major.

With respect to high school chemistry courses, most of the participants had unremarkable experiences, often comparing their chemistry courses to their more enjoyable biology courses, as one persister described:

> My chemistry experience…it was all right. I remember thinking, you know, "This is a lot more difficult than biology." I found biology a lot more interesting than chemistry just 'cause chemistry had more to do with math, like learning stoichiometry and things like that. I remember doing stuff like that and thinking like, "Man…" It was tougher and my teacher was a good teacher, just not very exciting or…thinking of cool things to do like my biology teacher had been, so it was a little bit more like, "Oh, well this is chemistry, something to get through."…So, I mean it didn't get me more excited about science, but…since it was more like math, it was like, you know, rules to learn. I don't know…it wasn't bad but it wasn't good, I guess. I knew that I wasn't going to have a great interest in chemistry for the rest of my life, you know.

In many cases, like the one above, the participants described their high school experiences as primary evidence of their future lack of interest in the subject. Similarly, a switcher described how his sophomore chemistry experience turned he and his classmates off to the discipline entirely:

> …we like memorized reactions and stuff like that…And we like did stuff like celebrate mole day, which is, you know, a mole is 6 x 10 to the 23 molecules, so we…oh, 6.02…so we'd celebrate like on a certain day. It's like February 6th, or something. And we had to do a stupid project…it was kind of a turn-off for chemistry…I don't really know anyone who liked chemistry in high school, so it was kinda like, "Ew, chemistry? I don't wanna do that" when it came for like, the fourth year science. You have to pick one and so not many people picked AP chemistry, and that's why, 'cause no one liked it the first time through.

Interestingly, this same student is now a chemical engineering major, in part, because he so enjoyed the college-level chemistry required for the biology degree.

Similar to their chemistry experiences, the majority of participants had unremarkable physics experiences. Some of these experiences were so unexceptional that participants had little to say about them, as exemplified by this description by this persister: "And then in 11th grade, we had physics and it was just, you know, the honors physics and it was more mathematics-type based. I mean, that's physics for you. I don't have much to say about it." Similarly, others, such as this persister, noted that their unremarkable high school experiences with the subject helped cement their interest in other disciplines, particularly biology.

> And then, junior year was physics and…as I went further, I went, "Yes, I'm still good at these, but they're less and less interesting to me." And physics is just not very interesting to me. Like I can do it, I can do the equations, you know, I got good grades in physics, but it wasn't fascinating to me the way that biology was fascinating to me.

Often noting the difficulties they had understanding physics, still others explained that they did not feel that they learned anything in their high school physics course, as described by this persister:

> So, junior year, physics…Not so good teacher. Didn't really learn anything…She was kind of young and disorganized and just wasn't that good at communicating the information. And actually, it kinda made me very disinterested in physics 'cause it was hard, I didn't really get it, and I didn't really see how it applied or anything. So, I really came away from that class probably with almost zero information…

The dichotomy between participants' biology experiences and chemistry or physics experiences was further demonstrated when I asked participants to report their best and worst experiences in high school science. Twelve reported that their biology courses were their best, whether Biology I (n=6), Biology II (n=3) or Anatomy and Physiology (n=3); three reported that Chemistry I was best; and one reported that Environmental

Science was her best. Of the 13 who had worst experiences,[29] six reported Chemistry I or Chemistry II were their worst; four reported Physics I was their worst; and three reported Biology I or Biology II were their worst. Two of these participants who reported biology as the worst also reported the same class as the best, citing that one part of the course made it the worst (e.g. the teacher), but another part made it the best (e.g. dissections). The other participant who named a biology course as worst also reported that Anatomy and Physiology was the best, noting that his later experience with anatomy and physiology formed the basis of his decision to major in biology: "And also, Mr. _____'s class was really my biggest influence. It's like, 'Hey, this is cool. Physiology, biology, I might like that.' So, that's why I decided to go do that." Overall, and as will be apparent among participants' reasons for choosing biology, much of students interest in biology and lack of interest in other disciplines, namely other sciences, figured highly in their decision to major in biology in college.

Table 4.9: Exemplary Quotes of Precollege Experiences Participants Reported as Important in Developing Their Interest in Biology (continued on next page)

Precollege Experience	Exemplary Quote
Educational Television	The program "Zoom." I'm such a nerd, man… I loved it and "Bill Nye the Science Guy."…I watched that like when I was in elementary school. That was great stuff, man…It was just a good show…I didn't have cable when I grew up, so pretty much I grew up on PBS and like the local cartoons, maybe on Saturdays. That was it 'cause everything else was like news or like adult TV, you know?...I'd just watch PBS the whole time. Again, a complete nerd.
Science Fair Participation	[Freshman year] I did a science project…and I tested water…from different places around town. So, I would go to the people that I knew, their houses, and I would go and…take a sample of the water…I tested it for nitrates, lead, chlorine, and something else, I don't remember…and I even made cultures with the water to see, you know, bacteria growing or whatever. I really liked that.

[29] Three of the participants did not have a worst experience, though they each had negative opinions about at least one of their science courses.

Precollege Experience	Exemplary Quote
Informal Science Experience	But the best experience I had in the science museums was when my parents took me to Houston and they have a life science museum, which is crazy, and it takes like three hours or four hours to go through the entire thing. I never went through the entire thing…I don't know if you've been there. It's awesome!
Family Member with Illness	My mother's aunt died of ovarian cancer and it was extremely painful and I thought…I wanted to help. I was like five at the time when I saw her and I really didn't understand what she was dying of. And it was crazy because…I'd never seen someone in so much pain and that was quite scary. And, I mean, a nurse would come to our house everyday to give her morphine and when I saw that I was just like, "This is crazy," you know, "Why would someone have to go through so much pain?"
Reading about Science	In 11th and 12th grade…I was really into like nonfiction reading or readings that had to do with biology. I read The Hot Zone for the first time, got really into viruses and so I read about different types of viruses. Eleventh grade I really got into AIDS and I was just like, "How are we to solve this problem? If I come up with it first, this is gonna be so great!"
Health Profession Internships	So…before I could drive, I started volunteering at _____ Hospital…I knew by then that and by now that no matter what it was, whether I need to major in bio or not, that I needed to do something with medicine and people, and, you know helping people…and…I loved it because it…like I could see the outcomes of certain aspects of biology, like diseases and stuff. And I was like, "Well, I wonder how this works?" and so I would want to learn about it.
Being a Patient	…I vividly remember like my surgeon, I recognize him to this day, when we go back and visit. And I just vividly remember being anesthetized and…I remember like the whole experience of being in a hospital and seeing the surgeons, seeing my parents, and then…everything was okay again. And then, I also remember just having to sit for hours while a man painted the glass eye that I have now. And so…from a young age, I had to learn how to take out my eye, wash it, put it back in, those kinds of things. And so, I just kind of developed an early interest of anatomy.

Sources of Personal Encouragement: Quantitative Results

Tables 4.10 and 4.11 present the precollege persons that encouraged persisters' and switchers' interest in biology, respectively. In both cases, high school biology teachers provided the most encouragement, followed by their mothers, fathers, and other adults (usually other relatives, based upon the interviews). As in the precollege experience results, there is little difference between switchers and persisters, implying that they again have the same suite of experiences prior to coming to college. Note that

this set of questions also asked about college personnel, the results of which are reported in a later section.

Table 4.10: Precollege Persons Who Encouraged or Discouraged Persisters' Interest in Biology (from most to least encouraging)

Source (-3 Greatly Discouraged to Greatly Encouraged +3)	N	M	Encouragement Score	Discouragement Score	Total Score
High School Biology Teachers	205	2	1.88	-0.07	1.80
Mother or Female Guardian	202	2	1.84	-0.06	1.78
Father or Male Guardian	197	2	1.78	-0.05	1.73
Other Adult/Family Member	193	1	1.31	-0.03	1.28
Middle School Science Teacher(s)	205	1	1.09	-0.06	1.02
Sibling(s)	186	0	0.95	-0.01	0.95
High School/Adolescent Friend(s)	203	0	0.86	-0.06	0.80
High School Counselor/Principal	195	0	0.44	-0.05	0.39
Childhood Friend(s)	196	0	0.35	-0.08	0.28
ES/MS Counselor/Principal	194	0	0.24	-0.06	0.18
Elementary School Teacher(s)	201	0	0.23	-0.06	0.17

Table 4.11: Precollege Persons Who Encouraged or Discouraged Switchers' Interest in Biology (from most to least encouraging)

Source (-3 Greatly Discouraged to Greatly Encouraged +3)	N	M	Encouragement Score	Discouragement Score	Total Score
High School Biology Teacher	110	2	1.65	-0.10	1.55
Mother or Female Guardian	110	2	1.62	-0.10	1.52
Father or Male Guardian	105	2	1.52	-0.04	1.49
Other Adult or Family Member	109	1	1.31	-0.06	1.26
High School/Adolescent Friend(s)	109	1	1.04	-0.04	1.00
Sibling(s)	101	0	0.87	-0.04	0.83
Middle School Science Teacher(s)	109	1	0.90	-0.08	0.82
Elementary School Teacher(s)	105	0	0.80	-0.06	0.74
Childhood Friend(s)	106	0	0.60	-0.07	0.54
High School Counselor/Principal	107	0	0.60	-0.07	0.53
ES/MS Counselor/Principal	105	0	0.44	-0.04	0.40

Mann-Whitney comparison of the persisters' and switchers' sources of encouragement revealed that switchers were more likely to rate distant associations, including peripheral school officials as encouraging their interesting biology (Table 4.12). The meaning of this difference is unclear, but the source of this difference is likely due to switchers rating college personnel as comparatively more discouraging than these persons from their childhood, as will be discussed later.

Table 4.12: Comparison of Persisters' (P) and Switchers' (S) Sources of Precollege Encouragement and Discouragement ($p<0.05$, in descending effect size order)

Source (-3 Greatly Discouraged to Greatly Encouraged +3)	M (P)	N (P)	M (S)	N (S)	M-W U	Z	Sig. (2-tailed)	Effect Size r
Childhood Friend(s) (P<S)	0	196	0	106	8773.5	-2.708	0.007[§]	0.156
ES/MS Principal (P<S)	0	194	0	105	8879	-2.602	0.009[§]	0.151
HS Counselor/Principal (P<S)	0	195	0	107	9184	-2.081	0.037[§]	0.120

[§]Exceeds Bonferroni-corrected p-value 0.0033

Sources of Personal Encouragement: Qualitative Results

Because so much of the encouragement that life story interview participants' described was in the context of specific experiences they had before high school, it was difficult to determine whether the person or the experience was more important in developing their interest. In an effort to divorce these two types, I coded experiences that included overt references to a person actively encouraging or discouraging an participant's interest as personal influences and ones that emphasized the activity, regardless of persons included, as precollege experiences (in the previous section). Table 4.13 presents summary results from the interviews, which echo the quantitative results. Mothers and fathers were not coded separately because both were mentioned at an equal rate by the participants.

Table 4.13: Persons Participants Reported as Encouraging Their Interest in Biology before College (in descending order of frequency effect size)

Persister Encouraging Influences (N=7)	Persister Frequency Effect Size	Switcher Encouraging Influences (N=9)	Switcher Frequency Effect Size
High School Biology Teacher	0.857	High School Biology Teacher	0.667
Parent or Guardian	0.714	Parent or Guardian	0.667
Other Significant Adult	0.429	Other Significant Adult	0.444
Siblings	0.333	Siblings	0.222
MS Science Teacher	0.286	MS Science Teacher	0.111

Table 4.14 presents exemplary quotes of each of the persons listed in Table 4.13. I separated mothers and fathers in this table to give examples of the different kinds of encouragement parents gave their children.

Table 4.14: Exemplary Quotes Describing Persons that Participants Reported as Encouraging Their Interest in Biology (continued on next page)

Person	Exemplary Quote
High School Biology Teacher	He was such a great teacher. He had this…electrophoresis lab. He could only pick three kids to do it because it was so expensive and so he picked me and two other kids, and I was just like, "Oh, my gosh!" And he's like, "It's based off of performance in class and interest in the subject." And I'm like, "Aw, I'm special!" And so, we ended up doing it…and only like one class was able to get results and it was our class. He wouldn't tell us who was the one who like actually did it right, and so we're like, "Aw, we're the smartest class!" and it was great.
Mother	We went to a lot of museums and [I was] enrolled in a lot of…summer programs…since the science museum was about an hour away, [my mom] would just sit there and basically wait the entire day for me to complete my activities. So she was very supportive and…was very concerned about my education.
Father	I've had my cat now for 14 years, so I remember one time…my dad telling me I had to do something constructive instead of just playing with the cat. And I was like, "This is constructive. I'm observing the animal." And he's like, "Okay, you have to like observe her behaviors and write them down." And so I actually did that and I gave him like a little report on my cat…I was probably like 10. My dad…was always like really supportive of my curiosity and…he would explain things to me when I was five that you wouldn't think to try to tell somebody.

Person	Exemplary Quote
Other Adult	[My grandmother] has a PhD in education, but she got her Bachelor's in bacteriology…I didn't get to see her that often and so what she did say, you know when I was around her, was just like, "Absorb it all" and "Wow" you know?…and so, of course, she would tell stories about when she was at the university and…how she would sit in her lab and she would get all these cultures and you tested different things and you can see how, on some of them…the bacteria died where you put this thing.
Siblings	I have two younger brothers. They're 16 and 14 and…I've been studying biology for a couple of years…but, you know, they ask questions, like, "Why does this happen?" and I like explaining it to them. It kind of encourages me 'cause if you study philosophy, it's kinda hard to apply that, you know? Like how do you? And so, with science, you know, anything like chemistry, biology, or physics, or anything like that, you know they can be like "_____, why is this happening?" you know and, sometimes I know and sometimes I don't, but I just find it really cool 'cause I know they remember that and they find it interesting too…
MS Science Teacher	Mr. _____, the teacher with the iguanas, he was really cool. He kept up with me past 7th grade into 8th grade and he was just making sure I was still doing well in my classes and, that's pretty much it. He was probably the first teacher that like ever like cared, but, yeah, he was my favorite teacher in the world.

CHOOSING THE BIOLOGY MAJOR

In both the questionnaire, the life story interviews, and focus group interviews, participants described why they chose the biology major, either in terms of their reasons or the decision process they underwent with regards to that choice. The following section is divided into two major parts, one quantitative and the other qualitative. The quantitative results section begins with a description of the demographic characteristics of the freshmen who choose biology and ends with a description of the reasons students choose biology, as reported in the questionnaire. The qualitative section describes the major reasons life story and focus group participants chose the biology major, as well as their evaluation of the decision-making process they used when choosing their major.

Choosing Biology: Quantitative Results

Who is Choosing Biology Their First Year?

Analysis of the 1654 freshmen biology majors entering The University between Fall 2000 and Fall 2002,[30] revealed that, in terms of gender, 63.9% were female and 36.1% were male (College of Natural Sciences, 2006a). In terms of generation, 87.6% of freshmen biology majors were traditional college students and only 12.4% were first generation college students. In terms of ethnicity 50.0% of the students were White, 27.0% were Asian-American, 17.6% were Latino, 4.2% were African-American, 0.7% were foreign (ethnicity unknown), and 0.4% were Native American. None of the above demographic categories were significantly different from the entire entering freshman class those same years.[31] In terms of advising area, 30.8% of biology freshmen started out classified in the health professions area[32], while 69.2% begin the major classified with no area or with another non-health professions area. Lastly, in terms of degree sought, 42.6% of biology freshmen started out as Bachelor of Arts majors and 57.4% started out as Bachelor of Science majors.

To determine if there were any interactions between entry demographic variables highlighted in this study, I performed Chi-square tests of Independence (Table 4.15) comparing the biology freshmen enrolled during the fall semesters of 2001 through 2004 (n=2056).[33] Based upon adjusted residual (AR) calculations[34], there were [1] more females initially seeking a Bachelor of Arts in Biology (2.7) and more males initially

---

[30] These years were chosen specifically to match the years used in survival analysis later.
[31] Chi-square results, not reported.
[32] Pre-medical, pre-dental, pre-veterinary, pre-pharmacy, and allied health professions.
[33] These years were chosen to match with the years sampled for the questionnaire used in the study.
[34] Adjusted residuals that are greater than two "contribute to the rejection of the omnibus chi-square test statistic at a statistically significant level." (McDonald & Gardner, 2000, p. 739). Note that adjusted residuals close to two are also reported to help explain additive sources of significance in non-dichotomous demographics, such as ethnicity. These numbers are reported in parentheses.

seeking a Bachelor of Science in Biology (2.7) than expected; [2] more first generation Latino students (9.2) and more traditional white students (7.9) than expected; [3] more Asian-American health professions students (3.6) and slightly more white (1.8) and Latino (1.7) non-health professions students than expected; [4] slightly more Latino (1.9) BA degree seekers and slightly more African-American (1.9) and white (1.8) BS degree seekers; and [5] more heath professions BA degree seekers (3.2) and more non-health professions BS degree seekers (3.2) than expected.

Table 4.15: Chi-square Results Comparing Demographic Groups

Demographic 1	Demographic 2	N	Chi-square	df	Sig.
Gender x	Generation	2056	2.644	1	0.104
	Ethnicity	2023[35]	3.501	3	0.321
	Advising Area	2056	1.828	1	0.176
	Degree Sought [1]	2056	7.279	1	0.007
Generation x	Ethnicity [2]	2023	101.505	3	0.000
	Advising Area	2056	0.236	1	0.627
	Degree Sought	2056	0.065	1	0.798
Ethnicity x	Advising Area [3]	2023	13.367	3	0.004
	Degree Sought[4]	2023	9.420	3	0.024
Advising Area x	Degree Sought [5]	2056	10.07	1	0.002

Important in these statistics is the attractiveness of the major to Latino students, and that this is not necessarily for reasons related to the health professions. Contrasting this is the attractiveness of the major to Asian-American students, who were more likely to be in a health professions area than the other ethnic groups. In addition and despite anecdotal evidence to the contrary, this association is not modulated by first generation status, such that both first generation and traditional college students were equally likely to be interested in the health professions at enrollment. Lastly, several of these significant interactions are modulated by the degree sought and health professions interest upon entering the biology major. The salient link between interest in health

[35] Due to the low cell counts for the Native-American, Foreign, and Other classifications, only the following ethnic groups were included: African-American, Asian-American, Latino/Latina, and White.

professions and choosing the general biology major (BA) rather than a specific biology major (BS), is not surprising, but the gender and ethnic interaction with this is. The implications of this are apparent in survival analysis of this population (addressed later in the chapter).

Reasons for Choosing the Biology Major

Tables 4.16 and 4.17 present the most important reasons persisters and switchers reported for choosing biology as their major, respectively. Although switchers and persisters noted some of the same reasons, the importance of those reasons is quite different. Three of the top four reasons reported by persisters concerned enjoyment and interest in biology and only one concerned future career plans, whereas the top four reasons reported by switchers all concerned future career plans. Whether this is the result of the *ex-post facto* nature of the study, such that persisters are more likely to claim they were interested then because they are interested now, for example, is indeterminate.

Table 4.16: Top Reasons Persisters (n=207) Reported Choosing the Biology Major (proportion > 0.50, in descending score order)

Reason (3 Moderately True of Me to Completely True of Me 5)	M	Score	Prop.
I liked biology	4.0	4.06	0.93
I thought that biology was the most interesting of the sciences	4.0	3.88	0.93
I was interested in learning more about biology	4.0	3.84	0.92
I thought that biology would best prepare me for my chosen career	4.0	3.68	0.85
I wanted to work in a health profession	4.0	3.43	0.77
I thought biology was fun	4.0	3.42	0.84
I wanted to help people	4.0	3.42	0.81
I was interested in anatomy and physiology	3.0	2.81	0.73
I did well in high school biology	3.0	2.78	0.72
It seemed like the best choice based on the options available to me	3.0	2.63	0.68
I thought biology was the best degree to have for professional school	3.0	2.61	0.62
I needed biology for my preprofessional educational requirements	3.0	2.33	0.56
Biology was easy for me	3.0	2.23	0.62
I was interested in cell, molecular, or developmental biology	3.0	2.07	0.55
I was interested in genetics or genetic engineering	3.0	1.95	0.51

Table 4.17: Top Reasons Switchers (N=112) Reported Choosing the Biology Major (proportion > 0.50; in descending score order)

Reason (3 Moderately True of Me to Completely True of Me 5)	M	Score	Prop.
I wanted to work in a health profession	4.0	3.64	0.82
I thought that biology would best prepare me for my chosen career	4.0	3.49	0.87
I wanted to help people	4.0	3.33	0.81
I thought biology was the best degree to have for professional school	4.0	3.15	0.75
I was interested in learning more about biology	3.0	2.83	0.77
I was interested in anatomy and physiology	3.5	2.78	0.70
I liked biology	3.0	2.77	0.72
I needed biology for my preprofessional educational requirements	3.0	2.73	0.68
I did well in high school biology	3.0	2.66	0.69
I thought biology was fun	3.0	2.63	0.71
I thought that biology was the most interesting of the sciences	3.0	2.63	0.67
It seemed like the best choice based on the options available to me	3.0	2.56	0.70
Biology was easy for me	3.0	1.81	0.52

Mann-Whitney comparison of switchers' and persisters' reasons for choosing biology (Table 4.18) demonstrates that persisters were more likely to report choosing biology due to their enjoyment and interest than switchers were (note the ten items marked with an asterisk). The first three reasons listed on Table 4.18 have large effect sizes, indicating a larger difference in the distribution of ratings between the groups. The next five reasons have medium effect sizes and only one of those results, "I thought biology was fun," is particularly salient based upon the larger medians for both groups. Another noticeable difference is that, despite some smaller effect sizes and the fact that the p-values exceed the Bonferroni-corrected threshold, where persisters were more likely to report their future pursuits outside of medicine or anticipation of future performance (marked with pluses). By contrast, switchers were more likely to report not knowing what to major in or the desire of others as part of their choice (marked with exes).

Table 4.18: Comparison of Persisters' (P) (N=207) and Switchers' (S) (N=112) Reasons for Choosing Biology ($p<0.05$; in descending effect size order).

Reason (1 Not at all True of Me to Completely True of Me 5)	M (P)	M (S)	M-W U	Z	Sig. (2-tailed)	Effect Size (r)
I liked biology*	4	3	6493.5	-6.784	0.000	0.380
I was interested in learning more about biology*	4	3	7098	-5.941	0.000	0.333
I thought that biology was the most interesting of the sciences*	4	3	7244.5	-5.737	0.000	0.321
I knew that I could do well in upper division biology courses +	2	1	8179	-4.622	0.000	0.259
I was interested in microbiology*	2	1	8236.5	-4.486	0.000	0.251
I thought biology was fun*	4	3	8206	-4.446	0.000	0.249
I thought I had to choose a major in order to be admitted to the University. (P<S) x	1	1	9151.5	-3.821	0.000	0.214
I wanted to do biological research or go to graduate school in biology +	2	1	8905.5	-3.627	0.000	0.203
I was interested in zoology, animal biology, or animal behavior*	2	1	9368.5	-3.068	0.002§	0.172
I was interested in genetics or genetic engineering*	3	2	9269.5	-3.044	0.002§	0.170
I was interested in cell, molecular, or developmental biology*	3	2	9286.5	-3.009	0.003§	0.168
My parent or significant adult wanted me to work in a health profession x	1	2	9746	-2.602	0.009§	0.146
I did not know what else to major in x	1	2	9801.5	-2.460	0.014§	0.138
I was interested in evolutionary biology*	2	1	9810	-2.428	0.015§	0.136
I was interested in conservation biology or ecology (P>S)*	1	1	10013	-2.369	0.018§	0.133
I wanted to teach biology (P>S) +	1	1	10127	-2.221	0.026§	0.124
Biology was easy for me (P>S)	3	3	9913.5	-2.201	0.028§	0.123
I thought that biology would best prepare me for my chosen career (P>S) +	4	4	10026.5	-2.082	0.037§	0.117

§ Exceeds Bonferroni-corrected p-value 0.0013

Table 4.19: Comparison of Persisters' (P) (N=207) and Switchers' (S) (N=112) Reasons for Choosing Biology (NS; in decreasing median order).

Reason (1 Not at all True of Me to Completely True of Me 5)	M (P)	M (S)	U	Z	Exact Sig.	Effect Size
I wanted to help people*	4	4	10860	-0.967	0.334	0.054
I wanted to work in a health profession*	4	4	11241.5	-0.471	0.639	0.026
I thought biology was the best degree to have for professional school*	3	4	10185.5	-1.835	0.067	0.103
I needed biology for my preprofessional educational requirements*	3	3	10572	-1.329	0.184	0.074
I did well in high school biology	3	3	11201.5	-0.510	0.611	0.029
It seemed like the best choice based on the options available to me	3	3	11214.5	-0.493	0.623	0.028
I was interested in anatomy and physiology*	3	3.5	11427	-0.215	0.830	0.012
I was not interested in any discipline besides biology	2	2	10160.5	-1.910	0.056	0.107
I majored in biology because I liked animals	2	2	10854.5	-0.996	0.319	0.056
I wanted to do conservation work	1	1	10652.5	-1.559	0.119	0.087
I was interested in botany or plant biology	1	1	10886	-1.421	0.162	0.080
My parent or other significant adult majored in biology	1	1	10832	-1.419	0.158	0.079
As a backup in case I did not get into professional school*	1	1	10680	-1.388	0.166	0.078
To please my parents	1	1	11023	-0.861	0.390	0.048
I wanted to work with plants	1	1	11331	-0.605	0.532	0.034
I wanted to work with animals	1	1	11300.5	-0.466	0.643	0.026
My parent or other significant adult encouraged/wanted me to major in biology	1	1	11328	-0.371	0.712	0.021
I was interested in marine or freshwater biology	1	1	11370.5	-0.342	0.733	0.019
Biology involved less or easier mathematics than the other sciences	1	1	11412	-0.273	0.789	0.015
As a backup in case I changed my mind about professional school*	1	1	11494	-0.151	0.880	0.008

Table 4.19 presents the non-significant Mann-Whitney comparisons of switchers and persisters in terms of their reasons for choosing the biology major. Based upon these data switchers and persisters are similar with respect to their desire for a career in the health professions (note the items marked with an asterisk). The statement "I wanted to help people" is included in this list because, as will be described in the qualitative results, helping others was generally synonymous with working in the health professions.

In addition, based upon Tables 4.18 and 4.19 switchers and persisters are similar in terms of their general lack of interest in the non-health professions related biology divisions, including zoology, ecology, evolutionary biology, botany, ecology, and most notably teaching. Contrast that with a much higher interest in anatomy and physiology, which interview participants often connected directly to medicine when describing this interest: "Probably because that's also the most tangible biological thing there was. I mean, you live with it everyday…just how the body works is amazing…and since I also wanted to be a doctor, I thought that also sort of correlated with that."

Table 4.20: Comparison of STEM Switchers (S) (N=51) and Non-STEM Switchers' (NS) (N=56) Reasons for Choosing Biology ($p<0.05$; in decreasing effect size order).

Reason (1 Not at all True of Me to Completely True of Me 5)	M (S)	M (NS)	U	Z	Exact Sig.	Effect Size
To please my parents (S<NS)	1	1	1017	-2.980	0.003[§]	0.288
My parent or another significant adult wanted me to work in a health profession	1	3	978	-2.971	0.003[§]	0.287
My parent or another significant adult encouraged/wanted me to major in biology	1	2	1032.5	-2.734	0.006[§]	0.264

[§]Exceeds the Bonferroni-corrected p-value 0.0013

To assess potential differences between switchers who left biology for non-STEM majors and those who left biology for STEM majors, I performed Mann-Whitney comparisons of their reasons for choosing biology. Tables 4.20 and 4.21 present the significant and non-

significant results of these comparisons. Overall, these two groups chose biology for the same reasons. Despite the lower medians and the fact that the p-values exceed the Bonferroni-corrected threshold, the differences (Table 4.20) show that non-STEM switchers were more likely to report being influenced or pressured to major in biology than their STEM switching counterparts.

Table 4.21: Comparison of STEM Switchers (S) (N=51) and Non-STEM Switchers' (NS) (N=56) Reasons for Choosing Biology (NS; in decreasing median order, continued on next page).

Reason (1 Not at all True of Me to Completely True of Me 5)	M (S)	M (NS)	U	Z	Exact Sig.	Effect Size
I thought that biology would best prepare me for my chosen career	4	4	1276	-0.986	0.327	0.095
I wanted to help people	4	4	1284.5	-0.945	0.348	0.091
I wanted to work in a health profession	4	4	1385	-0.285	0.784	0.028
I thought biology was the best degree to have for professional school	4	4	1413	-0.097	0.925	0.009
I was interested in anatomy and physiology	4	3	1248.5	-1.151	0.251	0.111
I thought that biology was the most interesting of the sciences	3	4	1292	-0.869	0.388	0.084
I was interested in learning more about biology	3	3	1196.5	-1.504	0.135	0.145
I thought biology was fun	3	3	1307.5	-0.781	0.437	0.076
Biology was easy for me	3	3	1371	-0.368	0.715	0.036
I did well in high school biology	3	3	1380.5	-0.304	0.765	0.029
I needed biology for my preprofessional educational requirements	3	3	1391	-0.236	0.818	0.023
I liked biology	3	3	1404.5	-0.151	0.882	0.015
It seemed like the best choice based on the options available to me	3	3	1419	-0.058	0.955	0.006
I was interested in genetics or genetic engineering	2	2	1369.5	-0.383	0.706	0.037
I was interested in cell, molecular, or developmental biology	2	2	1378.5	-0.320	0.752	0.031

Reason (1 Not at all True of Me to Completely True of Me 5)	M (S)	M (NS)	U	Z	Exact Sig.	Effect Size
I did not know what else to major in	2	2	1412	-0.104	0.925	0.010
I majored in biology because I liked animals	2	1.5	1416	-0.080	0.938	0.008
I was not interested in any discipline besides biology	2	1	1258	-1.132	0.262	0.109
I thought I had to choose a major in order to be admitted to the University.	1	1.5	1326.5	-0.696	0.492	0.067
I was interested in marine or freshwater biology	1	1	1230	-1.513	0.133	0.146
I wanted to do biological research or go to graduate school in biology	1	1	1219	-1.478	0.144	0.143
I was interested in conservation biology or ecology	1	1	1248.5	-1.417	0.160	0.137
I wanted to do conservation work	1	1	1265	-1.417	0.165	0.137
I was interested in botany or plant biology	1	1	1300.5	-1.402	0.149	0.136
My parent or another significant adult majored in biology	1	1	1313.5	-1.152	0.273	0.111
I was interested in microbiology	1	1	1283.5	-1.021	0.310	0.099
I knew that I could do well in upper division biology courses	1	1	1311.5	-0.832	0.409	0.080
I wanted to work with plants	1	1	1358.5	-0.823	0.424	0.080
I was interested in zoology, animal biology, or animal behavior	1	1	1319	-0.786	0.440	0.076
I wanted to work with animals	1	1	1344.5	-0.666	0.511	0.064
I wanted to teach biology	1	1	1362	-0.548	0.594	0.053
I was interested in evolutionary biology	1	1	1360.5	-0.473	0.639	0.046
As a backup in case I did not get into professional school	1	1	1373	-0.425	0.675	0.041
As a backup in case I changed my mind about professional school	1	1	1421.5	-0.049	0.969	0.005
Biology involved less or easier mathematics than the other sciences	1	1	1427	-0.007	0.992	0.001

Choosing Biology: Qualitative Results

Table 4.22 summarizes the qualitative results of participants' reasons for choosing the biology major, from both interviews and focus groups. Not only are the differences in frequency effect sizes noteworthy, so are the reasons reported by one group and not the other (bolded and footnoted). The next sections include descriptions of the sub-themes mentioned by at least one-third of switchers or one-third of persisters, in order of their descending frequency effect size. These sub-themes are: High School Biology, Interest in Biology, Parents, Helping Others, Lack of Interest in Other Subjects, Medical School, Ignorance, Appearance, and Job Options. Following these descriptions are exemplary quotes describing the less salient sub-themes (Table 4.23)

Table 4.22: Reasons Persisters and Switchers Participants Reported Choosing the Biology Major N=35 (in descending order of frequency effect size)

Persister Reasons for Choosing Biology, N=19	Persister Frequency Effect Size	Switcher Reasons for Choosing Biology, N=16	Switcher Frequency Effect Size
High School Biology	0.789	High School Biology	0.750
Interest in Biology	0.737	Helping Others	0.625
Parents	0.684	Parents	0.563
Lack of Interest in Other Subjects	0.579	Ignorance	0.500
Medical School	0.526	Interest in Biology	0.500
Helping Others	0.421	Medical School	0.500
Job Options[†]	**0.368**	**Appearance**[*]	**0.438**
Inspiration	0.316	**Biology Easy**[*]	**0.250**
Ignorance	0.263	Familiarity	0.250
Biology Broad[†]	**0.211**	Lack of Interest in Other Subjects	0.250
Avoidance of Math[†]	**0.105**	Inspiration	0.188
Biology Challenging[†]	**0.105**	Friends	0.125
Familiarity	0.053	**Necessary**[*]	**0.063**
Friends	0.053		

[*] Reported by switchers and not by persisters
[†] Reported by persisters and not by switchers

High School Biology

An overarching theme from both the life story and focus group interviews is that all of the participants based their choice of college major, in part, on their high school experiences. Although these sub-themes, including interest in biology, lack of interest in other subjects, or ignorance regarding their academic options, were teased out for the purposes of analysis, it is important to note that on some level all of these types of descriptions are grounded in the context of high school. Considering the above caveat, this section will only concern participants' direct references to choosing biology because of their high school biology experiences, namely their enjoyment of the subject or course, as modulated by their performance or their biology teacher.

At least three-quarters of persisters and switchers reported that they chose biology because they liked or enjoyed the subject in high school, as one persister succinctly explained, "It was just the thing that I liked the most." This default choice type of answer was quite common, as one switcher explained: "...if you don't like the classes, you don't want to take them. And when I finally got to choose what classes to take in things like high school and college, my only experiences in biology and stuff had been positive and so I was like, 'Well, I'll take these.'" For both persisters and switchers, some of their enjoyment of biology was modulated by their performance in biology, as another switcher explained:

> And I was good at it. I did well and all. It seemed pretty easy to get good grades and I liked being able to help other people in my class, teach them even. And I'm very much a person that likes to be the best at what I do and in high school, I was the best at what I did. It came easily to me and I really liked it…Oh, and I was just good at math, so that kind of just went along with it…Because I was good at bio and sciences and maths, I just immediately looked to where in the math/science area was I going to actually go into. It never really crossed my mind to do anything else basically.

For about one-third of persisters, but curiously not for switchers, some of their enjoyment of biology was modulated by their high school biology teacher, as another persister explained: "…I had AP bio senior year in high school and I really liked the teacher and I really liked the class, so that kinda helped me choose biology when I got here."

Interest

The second most reported reason for choosing biology by persisters and fourth most (tie) reported reason by switchers was their interest in biology. Though the roots of this interest began in childhood, for many of the participants, this interest was not developed intellectually until high school (as described above). This makes sense considering students are not introduced to the more complex life science curricula, such as cell and molecular biology, until they are in high school. Many of these descriptions of interest were rather general and involved little explanation, such as: "…it's really interesting. I really like it…I don't know how to explain it. I guess kinda like it peaks my interest." In addition, several of the participants with some general interest also noted that a specific interest in a biological field was a primary reason for choosing biology, as one persister explained: "When I was in…high school, it was like the peak time of genetics research coming up. They had the human genome project going on and I don't know, at the time, I thought it could be answers for many things." All of these specific interests were either related to direct instruction in high school or, as in this case, biological advances contemporaneous to the participants' adolescence.

Parents

The third most reported reason for choosing biology by both switchers and persisters was the influence, modeling or support from their parents. Both switchers and persisters noted that their parents directly influenced their choice of biology, often with

the expectation that they would go to medical school or by directly pressuring them to do so, as one switcher described:

> …I had a lot of fears about money, first of all, pressure from my parents to support [myself]….They were pressuring me about med school, generally. They…thought I didn't need to [go to] med school, but they said biology was good, "You should do this." I really didn't know what I wanted to do. So, I decided to do biology…

Similarly, a persister explained how she felt her parents expected her to become a doctor:

> This sounds really cheesy, but it really was just my parents, growing up and saying "You're gonna be a doctor, right?" Seriously, like I always felt like they expected that of me and I also wanted to…have a good career, have something challenging to do, achieve something. So, that was my first like, "Oh, science, doctor." Yeah, and then I found that I really liked it.

Some of the participants viewed their parents as models for what they should (example) or should not do (anti-example) in their academic or career life. For example, another persister explained that she chose biology and the medical profession because of her father's example:

> Well, I grew up around it. We would be at the dinner table, literally eating stuff, talking about the grossest medical diseases, treatments. I mean, my dad was internal medicine…he calls it 'Infernal medicine,' the worst job of the doctors, or whatever, but he still loved it. So, I saw how much he loved it and…he just worked really, really hard all of the time. So, you would've thought that that would completely turn me off, but for some reason it didn't, I don't know why. And then my mom's a nurse practitioner and I saw her go back to school here and get her Master's and I just kind of thought, "Oh, you know, I think I would want to do more than just four years."

The other and more frequent type of modeling of parents was the anti-example, whereby the participant chose biology to avoid having the same profession as a parent, or avoid the lifestyle associated with their parents' job, as another switcher explained: "Political science kind of interested me, but not law school so much 'cause my dad was a lawyer and I didn't really want to do the same thing." In a similar fashion a few of the persisters specifically noted wanting to work outside and not wanting to have an office

job like one or both of their parents, as another persister explained about a focus group card he entitled "Talk about my weekend at the water cooler:" "Like my dad had a corporate job and he was just miserable, you know, and there's like no way that I'm gonna end up in a cubicle, pushing papers, talking about my weekend at the water cooler. There's just no way I'm gonna let that happen."

The last reported parental effect was that of support or encouragement. These types of responses differed from those conveying expectation or pressure, because the participants described either their parents encouraging their interest in nature or medicine in an informal context, or their parents supporting their academic interest in science or biology. In many cases, this support came in the form of the relationship itself, as another persister explained a focus group card she entitled "My dad and I have always connected with science:"

> Well, my dad has a Master's in like engineering, which I have no interest in, but he's just very like into science I guess. It's like whenever new news would come out with like science-related things, we'd always talk about it. And my brother is just kind of out-there and my sister is definitely a liberal arts person and my mom majored in English and communication, so really, me and my dad are the only ones that are like fascinated with new diseases or, you know, just new like evolution stuff, or environment stuff. So, we've always, since I can remember, really talked about science stuff. In high school, out of math, history, English, whatever classes we took, I was just "Eh, whatever." But I did them and bio was really the only one that I'd come home and be like, "Hey dad, guess what I learned today."

Similarly, another persister described her parents' encouragement during childhood as a reason for choosing biology in college.

> …and my parents were like super-big hippie bird-watchers…even though my dad works in, you know, corporate industry…but still I was always taught from like as young as possible like, "Look how amazing this living thing is," and like, you know, "Look at the world growing around you," blah-blah-blah. And like, my dad, I just found out a couple of years ago, like actually hunted, but would have never let us know that when we were kids, 'cause he wanted…my brother and I to be so like reverent for living things and this and that, so, not that I have anything against hunting, so…Yeah, so definitely like a childhood thing. Like I said

> before, I would have never chosen anything else, I don't think,…My parents were like, "Toys and TV? Yeah right. Go find some dirt." And I'm really glad that I grew up like that.

Important among these results are that, while switchers and persisters were equally likely to mention the support or encouragement they received from parents (0.211 versus 0.188), persisters were more likely (0.316 versus 0.188) to mention their parents as an example/anti-example and switchers were more likely (0.375 versus 0.211) to mention their parents as expecting or pressuring them to major in science or become a doctor.

Helping Others

The second most-reported reason for choosing biology by switchers and sixth most reported by persisters was helping others. When I asked the 18 participants who reported this as a reason for choosing biology what they meant by helping people, 13 described working in the health professions, four described performing research (with two explaining that their research would involve testing pharmaceuticals in the context of being a doctor), and one described teaching as a means to help people.

To further explore the connection between medicine and helping people, I asked the following question to those mentioning the medical profession specifically: "There are a lot of ways to help people, how did you decide that being in the medical profession was how you wanted to help people?" Four of the thirteen participants explained that being a doctor was a tangible or immediate way to help people, often juxtaposing it to research, as one persister explained: "…being a doctor, you're tangibly sort of helping a person whereas if you're doing research, you're coming up with some abstract knowledge that somebody else will put into action for you." Another four participants explained they had a personal reason for wanting to help people with medicine, usually coping with a personal illness or the illness or death of a family member, as one switcher explained: "I think I chose it because of my experiences with doctors and my grandma,

who died of lung cancer." Another four participants did not have an answer for the question, for example, one switcher asked: "What are some other ways?" and after I listed off several professions that involve helping people, such as social work, urban planning, law, teaching, he continued: "I think it's default, as in not wanting to do any of the other things." The thirteenth participant explained that he wanted to help people by being in the medical profession because of the fringe benefits:

> I think it was just a lot of money…and you were…someone important, you know? I'm a leader…by nature… I take charge…and so, I've always felt…some desk job was never gonna be enough for me, you know? I feel that like I need some important job that made lots of money that made me someone influential, you know? So I could leave my mark somewhere, I guess.

While only one participant admitted a personal connection between helping people and prestige or money, it is noteworthy that only two of the other twelve mentioned volunteering their services as a means of helping people. This and the fact that several openly discussed the outwardly altruistic and inwardly pecuniary motives of "other" students implies that money or prestige may be more common motivating factors than participants let on, as three switchers discussed in a focus group (italics and bold designate the different persons):

> Everybody's just obsessed with medical school and it's [like, and you know…]
>
> *[Yeah* **=Mm-mm]**
>
> …a joke…"Well, what's your major?" "Premed."…everybody's premed, and everybody's going to medical school, everybody's gonna be a doctor. And if you're gonna be a surgeon, you're gonna be a burn surgeon not a plastic surgeon, not the boob surgeon.

Lack of Interest in Other Subjects

Over half of persisters and a quarter of switchers reported choosing biology not necessarily due to their interest in biology, but their lack of interest in other disciplines, as one persister explained: "I don't know why I chose [biology]. I didn't like anything

else. There wasn't anything else that interested me." Much of this directed interest was developed during high school, as one switcher explained: "I never had any classes…in high school that interested me, except for bio. Everything else I knew I could learn, I could get good grades in, but it was never something I could choose…[and say] 'Oh, that's fun. I wanna do that.'" Adding to this is that, although most of the participants reported being interested in different areas of science from a young age or knowing they wanted to study science in college, the majority chose biology, in part, because of poor, unremarkable, or otherwise difficult experiences in other high school sciences (as previously discussed), as another persister explained: "At the time, I was like, 'I can major in biology. I can major in chemistry. Or I can major in…' I had to major in a science, and I was like, 'I hate chemistry. I don't wanna take that and I love biology.'" Similarly, as another persister noted, although he was interested in biology, his choice was largely based upon a process of elimination:

> Well…I got a 5 on my AP calculus [exam]. I mean, I could do math, I just wasn't interested in that. So, math and engineering, I just kicked aside. Computer science, I sort of had an interest in, but I…felt I wasn't good enough at a college level. I just did it sort of for fun. That wasn't an option. And then that left me with biology and chemistry. And…I didn't enjoy chemistry too much. So, biology was the last one.

All of these participants had narrowed their options to the sciences prior to coming to college, whether due to their perception that they had to major in a science or due to their ignorance of other options (discussed later).

Medical School

Interest in the medical profession also figured prominently in students' initial interest in biology and choice of biology as a major, with half each of persisters and switchers choosing the major for this reason. The most prevalent of these types of responses was that biology was a default choice for medical school, as one persister

explained: "Number one…it's like the premed default major. So I was like, 'What the hell' you know, like that's how I picked my major, like 'Whatever.'" In addition, many of these same participants reported choosing biology because they did not know what else to major in, presumably because they believed biology to be the pathway to medical school, as one switcher explained:

> Honestly?...I thought that's what you were supposed to do, premed. Like I thought…it was necessary to major in biology because you took so much biology…And, thinking that's what the path I was supposed to take to, you know, be premed. It turns out, it's not and most of the premed students really aren't…

Interestingly, only a couple of these participants could pinpoint the source of this information, most often stating their college advisor or high school counselor "led them to believe" they should major in biology. The remaining participants who evidently were not told they should major in biology to go to medical school explained that the connection between the two was obvious, as another persister reported: "It seems logical. I know it's not true. I mean, I've long since known that's not true..."

Another reason for choosing biology was as preparation for medical school, as another persister explained: "…the reason I decided to be a bio major was a culmination of…wanting to do something that would prepare me for medical school." For a few of these participants, majoring in biology was only about academic preparation; for others, majoring in biology was also about remaining competitive in medical school, as another persister explained:

> Well, I was thinking in medical school, you're gonna be pretty much learning the same kind of things as you would in like a science major, so I think…majoring in biology would prepare you more for medical school 'cause you'd already have like a basis for the other classes…'cause…if you…majored in an easy major or something, and went to medical school or something like that, I think you would have a hard time in medical school.

A third reason participants choose biology for medical school was out of, what participants termed, convenience or the coincidence of requirements, as one persister

explained: "Because the requirements are only a class or two different from premed requirements and biology, I thought that was the best major." In similar fashion, another persister related this coincidence of requirements to graduating on time: "I kind of thought it was a plus that I could do my premed requirements and compare that with my bio degree requirements, and that it would coincide. So that was handy 'cause I wanted to graduate in four years."

Ignorance

Another salient reason for choosing the biology major for persisters, and more so for switchers, was "not know[ing] what to major in." While any choice based upon limited informational resources (i.e. high school coursework) could be considered as one made out of ignorance, only participants' direct references to not knowing what to major in were coded in this manner. Whether ascribed to a lack of knowledge of their interests or a lack of knowledge of their options, all participants who described choosing biology out of ignorance did so with a direct reference or allusion to the pressure they felt to choose a major when either applying to college or upon enrollment, as one switcher described: "I mean, I didn't really know what I wanted to study, even back then, I guess there was a little bit of a crisis initially. I had like no idea what direction I'm going."

The majority of these participants did not know what to major in because of a lack of knowledge of their options, as one persister explained: "…I didn't know all the options that I had, so you know, I was thinking… 'What else would I do if I didn't major in biology?'" Most often these types of explanations were accompanied by a description of the options unavailable in high school, as another switcher explained: "…I didn't know too much about [it] 'cause I never did business in high school, so why would I do something that I totally don't know about in college?" Similarly, another persister

explained that she chose biology when she applied to The University, in part because, as compared to other options, it seemed like her best option:

> Well…there are different schools I had to choose from…I didn't know what liberal arts was, for one thing…I wasn't interested in business---it's not my kind of thing. Engineering was way out of the question…but of all the choices…biology seemed more my kind of thing to do.

Other explanations for this lack of knowledge about options were tied to a desire to go to medical school as well, as one switcher explained: "I already decided I wanted to do medicine…so I decided that since…I was only interested in science, biology was…the best thing to major in because I didn't really know what else to major in. So it was just what I could major in to go into medicine."

When I asked these participants why they did not know about their options, participants had one of two explanations: the lack of information about majors coming from The University itself and a lack of research or exploration on their own part (either before or during the first year of college). Concerning the lack of information about options, three persisters discussed this in terms of the application process (italics and bold designate the different persons):

> …you can ask somebody what HDF[36] is and nobody's gonna know. I wish so badly that I knew what HDF was now, like I wish in the worst way, but I didn't know what it was…Oh, I know what it stands for. I don't know what that means in like practicality purposes.
>
> *He's right, I mean…when you're actually online for admissions and they ask you to pick a major or something, they give you this list of majors, but they don't tell you what exactly you're gonna be doing.*
>
> **I agree, like when you do the application online, it's just a scroll-down and I'm like, "What is that?" and you just choose at random.**

Concerning the lack of research, one persister explained: "I think I would be good at other things, like creative things or journalism or English, but I don't even know what I

[36] Human Development and Family Sciences

don't know." So I never explored any of that. So, I just kind of chumped out, didn't take a risk."

Appearance

Almost half of the switchers and none of the persisters reported choosing the biology major because it "was credible," "looked good," "sounded impressive," or was a "serious major," in comparison to other majors, including other disciplines in which they were interested, as one switcher explained:

> …it's a serious field. I mean, there's an idea that I had going into college that, "Okay, I can't just go in there and take something idiotic."…And you know, science is generally thought of as something that's much more serious and much more valuable than other things. And that may or may not be true. I don't know. That's just the whole impression I got. "And I need to do this because this is something that other people think is important. It must be important. I'm going to college and so, you know, gotta do something that's actual education," you know, and that's generally my attitude going in.

Similarly, another switcher explained that she wanted to be viewed as someone who took her education seriously.

> …I think I always knew I was better at English, but I went with biology because I liked it a lot and… I know I heard this a couple of times in high school that, "Oh, if you're an English major, you're really just going out for an MRS and you're not a serious student." That kind of…deterred me from majoring in English from the start.

For a few of these switchers, the perception that biology was a serious or "real" major was cemented by the treatment they received from their relatives and peers. One switcher explained the difference in the way people regarded her when she told them her major:

> Oh, people were impressed…And so I wanted to be a teacher and I was initially enrolled in education and so when I told everyone, they're like "Great. You're in education. That's so nice. You'll be such a good teacher. Blee-blah-blah." But then, whenever I had to switch into biology because, you know, you have to just get the education certificate, people were like, "Wow. That's hard." Like

> engineering is respected and science is respected. Like if you're in liberal arts or communication or education, you're fluff.

Interestingly, five of the seven switchers who mentioned appearance as a reason for choosing biology, ended up majoring in the discipline they avoided choosing their first year of college.

Job Options

A reason mentioned by over a third of persisters, but none of the switchers, was choosing biology because of the job options stemming from the major, often in comparison to other disciplines, as one persister explained: "…it just seemed like a good, like a safe major, like…if I had this degree, I could pretty much do whatever I wanted. I wouldn't be stuck with like flipping burgers at McDonald's, which is what I would've done if I would have done philosophy, you know, or like English, which was also one of my other interests." For a few, the relationship between biology and job options had to do with money, as another persister discussed with other members of his focus group:

> I guess this is probably gonna sound real materialistic, but one of the reasons why is just 'cause I wanted to have a future. I wanted to have, to at least be some, successful in some sort of fashion…And not have to be, you know, on The Drag somewhere begging for change 'cause I'm a philosophy major. No offense to them. That's just the way I saw it. I just wanted to, you know, do things when I graduate, except just going home.

For others, the relationship between biology and job options was one of security, as another persister explained:

> Well, for me, I figured if I was going to go to college and go for four years, and work to get a degree, I wanted to do something with it. I mean, I could've done something in liberal arts or, which would've been more interesting to me, but I'm not gonna get a job with that. And, right now, that actually is useful to me, 'cause I'm looking for a job and it's good to know that I have a BS and I'll be able to get a job somewhere. It might not be the best job in the world, and it might not be my lifelong dream, but, you know…I have some security there, at least.

As mentioned previously, Table 4.21 presents exemplary quotes from the remaining sub-themes concerning choosing the biology major. Items marked with an asterisk were only mentioned by switchers and ones marked with a cross were only mentioned by persisters.

Table 4.23: Exemplary Quotes Describing Participants' Other Reasons for Choosing Biology

Reason	Exemplary Quote
Inspiration	And then, like growing up, I was always watching National Geographic and "Nova" and "Nature" and all those really cool programs. David Attenborough was like my hero when I was a kid. And then like, in high school, it all became…"Who has the biggest teeth? Who kills the most things?" you know? And it was like led by goons like Steve Irwin, may he rest in peace, and Mark O'Shea…Mark O'Shea was a moron…I don't know how he got his own show. David Attenborough, with his shows, you like learned about everything. Like, "Here's a sparrow. Let's learn everything we can about this common sparrow." And then, like these guys were like, "Oh, crocs can kill you," like that's the only reason we should learn about them, and all this stuff. And I felt like we were building this culture of ignorance.
Biology Easy*	Biology, I never really found to be difficult. Every class I've always made A's in just because it's something that I can enjoy reading about. I don't…have to try to learn it. It comes naturally…I can read it and I'm like, "Oh, that makes sense" rather than, "Oh, let me just sit here and think about how to make it make sense."
Familiarity	I was just more familiar with biology, so…I chose that one.
Biology Broad†	…I thought I really liked science, but I wanted to go into something that sort of was broad, that sort of encompassed different, you know, subjects of science, like physics, chemistry, ecology, physiology, and stuff like that, and biology sort of encompassed all of that.
Friends	…and most of my friends from high school were doing biology
Biology Challenging†	…and I also thought it would be challenging…I didn't wanna do something really easy in college…that wouldn't be hard for me. I wanted to do something that would make me work hard and just grow and all that good stuff, prove that I'm not perfect and all that.
Avoidance of Math†	…biology is the science with the least math. I actually like physics. I don't like chemistry all that much 'cause it's too meticulous, but it's all that math and they ruin all that good science with math stuff.
Necessary*	"Necessary" means that I wanted to be a teacher…and I thought that you could be a teacher through education, but then found out that I had to be a biology major…

* Switchers only
† Persisters only

Evaluation of the Decision-Making Process

To better understand the process life story participants used to choose biology as their major, I asked them to evaluate their decision-making process with a "what if?" question: "Suppose you could go back to the time during which you were deciding your major, what would you do differently and what would you do the same?" The most common response to the former part of the question was to do more research: six of the nine switchers and five of the seven persisters would have done more research before and during their first semester of college. This research included taking AP biology to see if they really liked the subject, asking professors or advisors about specific majors, asking other students about their majors and which professors to take or avoid, and spending more time researching their options in general. The other three switchers reported that they would have picked their current major to begin with; the other two persisters reported that they would have chosen a different biology concentration.

As far as what they would have done the same, all of the persisters and four of the switchers explained that they would have still chosen biology as a major. Two of these switchers acknowledged that they would not be in their current major had they not began their college education in biology, as one switcher explained: "Based on what I know now…it's interesting because…I wouldn't do too much different because I'm so stubborn, you know?...I would've still wanted to be a doctor. I don't think I would've ended up in government any other way." The other two switchers explained that being in the biology major helped them transition into college:

> …I guess I would never know biology was gonna be that hard unless I'd taken it. And I would never know how hard college was gonna be unless I failed a couple of things, so I guess I would still do those classes and it would teach me, you know?...I learned from it, from failing at it. I actually succeeded in the end 'cause I know how to do better now. I learned from my mistakes, whereas before, I never had mistakes. It was just…always good.

EXPERIENCES IN AND PERCEPTIONS OF THE BIOLOGY MAJOR

To elucidate and compare persisters' and switchers' perceptions of the education they received while in the biology major, participants evaluated their college science experiences. The next section presents results from both the questionnaires and interviews: the quantitative then qualitative results concerning college biology experiences and the quantitative then qualitative results concerning college biology personnel.

Perceptions of the College Biology Experience: Quantitative Results

Tables 4.24 through 4.27 present the significant and non-significant results of Mann-Whitney comparisons of persisters' and switchers' ratings of how various aspects of their biology experiences affected their overall opinion of the biology major. These results are separated into four tables based upon effect size: large, medium, small, and non-significant results. Results demonstrate that persisters had significantly higher ratings than switchers on 45 of 48 of these items, indicating that persisters' experiences were much more positive than switchers.' Based upon the median ratings and the percentages of responses within each rating, switchers were more inclined to rate most of these aspects as having no effect on their overall opinion (0), whereas persisters were more inclined to rate most of these aspects having a slightly positive effect on their overall opinion (1). Due to the *ex post facto* nature of the study, it is unknown whether switchers' opinions were generally lower because: they actually had poorer biology experiences than persisters, they had comparatively better experiences in their new major, or both. I chose not to ask switchers to rate their experiences in their new major in comparison to biology because of the varying lengths of time they had been in their new major. This decision was supported by the finding during qualitative data collection that

several switchers had only taken one or two courses in their new major at the time of the interview.

Table 4.24 presents the difference that had the largest effect sizes, with three of the most significant differences concerning student outcomes (marked with an asterisk) and the remaining were either directly referencing instructors or the courses themselves. Observe that these large differences are due to the almost opposite distribution of responses between switchers and persisters, where switchers' responses were positively-skewed and persisters were negatively skewed.

Table 4.24: Comparison of the Effects of Persisters' (P) and Switchers' (S) Opinions of Aspects of the Biology Major ($p<0.05$, in descending large effect size order)

Effect (-3 Greatly Negative to Greatly Positive +3)	M (P)	N (P)	M (S)	N (S)	M-W U	Z	Sig. (2-tailed)	Effect Size r
My understanding of biology*	2	174	0	97	3890	-7.537	0.000	0.458
The biology lecture(s)	1	174	0	96	4142.5	-7.021	0.000	0.427
My grades in biology course(s)*	1	174	-1	97	4478	-6.479	0.000	0.394
The overall learning experience provided by my biology courses	2	174	0	97	4736	-6.102	0.000	0.371
The degree to which my biology grades reflected my understanding of the material*	0.5	174	-1	95	4843	-5.686	0.000	0.347
The biology laboratory course(s)	1	166	0	74	3589	-5.241	0.000	0.338
Biology instructors' ability to communicate information	1	174	0	96	5140.5	-5.345	0.000	0.325
Biology instructors' helpfulness	1	172	0	97	5388	-4.966	0.000	0.303

Table 4.25 presents the differences with medium effect sizes, with over half of these items related to or included some aspects of teaching, such as content knowledge, attitude, teaching ability, environment, and availability (marked with asterisks). Table 4.26 presents the differences with small effect sizes, all of which exceed the Bonferroni-corrected p-value threshold. Three-quarters of these items concern TAs and advisors, indicating their limited role in the overall opinions of both switchers and persisters.

Table 4.25: Comparison of the Effects of Persisters' (P) and Switchers' (S) Opinions of Aspects of the Biology Major ($p<0.05$, in descending medium effect size order, continued on next page)

Effect (-3 Greatly Negative to Greatly Positive +3)	M (P)	N (P)	M (S)	N (S)	M-W U	Z	Sig. (2-tailed)	Effect Size r
Biology instructors' attitude towards me*	1	171	0	96	5443	-4.733	0.000	0.290
The degree to which the biology exams reflected the material presented in lecture	1	173	0	96	5514	-4.675	0.000	0.285
Biology instructors' attitude towards students in general*	1	171	0	95	5494.5	-4.508	0.000	0.276
The availability of biology research opportunities	1	150	0	72	3682	-4.041	0.000	0.271
The biology exams	0	174	-1	96	5660	-4.445	0.000	0.270
Advisors' ability to give me individualized attention	1	165	0	85	4807	-4.185	0.000	0.265
Biology instructors' biology content knowledge*	2	174	1	97	5861	-4.284	0.000	0.260
Biology instructors' ability to teach*	1	174	0	96	5800	-4.240	0.000	0.258
The learning environment of my biology classes*	0.5	174	0	95	5808.5	-4.164	0.000	0.254
Biology TAs' biology content knowledge*	1	173	0	96	5911	-4.047	0.000	0.247
Biology TAs' availability outside of class*	1	165	0	90	5368	-3.930	0.000	0.246
The precision which the biology exams tested my understanding of the material (P>S)	0	173	0	96	5934.5	-3.949	0.000	0.241
Biology instructors' availability outside of class*	1	170	0	91	5605	-3.844	0.000	0.238
Biology instructors' ability to manage the classroom*	1	174	0	96	6105.5	-3.883	0.000	0.236
Biology TAs' attitude towards me*	1	172	0	96	5991.5	-3.867	0.000	0.236
The opportunities for discussion during biology lectures* (P>S)	0	170	0	91	5613.5	-3.798	0.000	0.235
The opportunities for discussion during biology discussions*	1	172	0	92	5754.5	-3.795	0.000	0.234
Biology TAs' helpfulness*	1	171	0	96	5966	-3.812	0.000	0.233
Advisors' attitude towards me	1	164	0	85	5124.5	-3.516	0.000	0.223
The biology discussion section(s)	1	173	0	93	5968	-3.561	0.000	0.218
Advisors' ability to help me choose courses	1	167	0	87	5382	-3.468	0.000	0.218

Effect (-3 Greatly Negative to Greatly Positive +3)	M (P)	N (P)	M (S)	N (S)	M-W U	Z	Sig. (2-tailed)	Effect Size r
The opportunities for interaction with other students during biology discussions (P>S)*	1	170	0	91	5844.5	-3.396	0.001	0.210
Biology TAs' attitude towards students in general*	1	170	0	94	6055.5	-3.392	0.001	0.209
Biology instructors' use of technology during lecture* (P>S)	0	169	0	96	6246.5	-3.387	0.001	0.208
Biology TAs' ability to communicate information*	1	173	0	95	6209	-3.396	0.001	0.207

Table 4.26: Comparison of the Effects of Persisters' (P) and Switchers' (S) Opinions of Aspects of the Biology Major ($p<0.05$, in descending small effect size order)

Effect (-3 Greatly Negative to Greatly Positive +3)	M (P)	N (P)	M (S)	N (S)	M-W U	Z	Sig. (2-tailed)	Effect Size r
Advisors' ability to adapt his/her general advice to me and my needs	0.5	164	0	87	5465	-3.127	0.002[§]	0.197
The opportunities for interaction with other students during biology lectures (P>S)	0	164	0	93	5973	-3.042	0.002[§]	0.190
Biology TAs' use of technology during discussion (P>S)	0	167	0	93	6266.5	-3.055	0.002[§]	0.189
Biology TAs' ability to teach	1	172	0	96	6430	-3.076	0.002[§]	0.188
Advisors' ability to assist me with academic difficulties (P>S)	0	146	0	81	4614.5	-2.805	0.005[§]	0.186
Advisors' knowledge of major requirements	1	166	0	87	5641	-2.946	0.003[§]	0.185
The grading policies or procedures in my biology courses (P>S)	0	172	0	96	6621	-2.760	0.006[§]	0.169
Advisors' attitude towards students in general (P>S)	0	145	0	73	4307	-2.340	0.019[§]	0.158
Advisors' knowledge of university policies and procedures (P>S)	0	161	0	87	5779.5	-2.376	0.017[§]	0.151
Advisors' ability to assist me with non-academic difficulties (P>S)	0	117	0	74	3636.5	-1.968	0.049[§]	0.142
The biology laboratory facilities	1	168	0	72	5099	-1.975	0.048[§]	0.128
Biology TAs' ability to manage the classroom (P>S)	0	172	0	96	7092.5	-2.080	0.037[§]	0.127

[§]Exceeds Bonferroni-corrected p-value 0.001

Table 4.27 presents the non-significant differences, all of which are facilities offered for biology students. That these are not significant validates the questionnaire because, realistically, these factors should not be affecting their overall opinion of the major.

Table 4.27: Comparison of the Effects of Persisters' (P) and Switchers' (S) Opinions of Aspects of the Biology Major (NS, in descending median order)

Effect (-3 Greatly Negative to Greatly Positive +3)	M (P)	N (P)	M (S)	N (S)	M-W U	Z	Sig. (2-tailed)	Effect Size r
The life science library facilities	1	151	0	74	4736.5	-1.951	0.051	0.130
The biology computer lab facilities	0	131	0	56	3186.5	-1.590	0.112	0.116
The biology classroom facilities	0	174	0	94	7827	-0.628	0.531	0.038

Tables 4.28 and 4.29 present the most important positive experiences of persisters and the most negative experiences of switchers, respectively, to better understand which of these items was most important in affecting persisters' and switchers' overall opinion of the major.[37] While these are not necessarily the reasons persisters stayed and switchers left the major, they represent the factors that, as rated by the majority of each group, had the greatest effect on overall opinion of the biology major, whether positive or negative.[38] Table 4.28 shows that several of the persisters' positive experiences related directly to instruction, but the most positive effect was persisters' own perception of their understanding of biology. By contrast, Table 4.29 shows that all of switchers' most negative experiences had to do with assessments and performance outcomes. Interestingly, the majority of persisters did not rate their grades as positively affecting

[37] There were no factors which the majority of persisters rated as negatively affecting their opinion of the biology major; and there were no factors which the majority of switchers rated as positively affecting their opinion of the biology major.

[38] Comparatively unimportant items (ones that more than 1/3 of either persisters or switchers rated as having no effect, e.g. "0") were excluded from consideration, regardless of how significantly different switchers and persisters scored. For example, 47% of persisters and 61% of switchers rated the instructor's use of technology as having no effect on their overall opinion of the major, which indicates that, even if this had a positive/negative effect for one or both groups, it was not important overall.

their opinion of the biology major. As uncovered during qualitative data collection, all of the persisters, including those with 4.0 GPAs, reported having difficulties with or having to "work hard" in one or more of their biology courses (discussed later).

Table 4.28: Aspects of the Major that Persisters Reported as Positively Affecting their Overall Opinion of the Biology Major (Positive Effect Score > 1; Proportion reporting as no effect < 1/3; in descending total score order)

Effect (-3 Greatly Negative to Greatly Positive +3)	N	M	Positive Effect	Negative Effect	Total Effect
My understanding of biology	174	2	1.82	-0.09	1.73
Biology instructors' biology content knowledge	174	2	1.64	-0.09	1.55
The learning experience provided by my biology courses	174	2	1.56	-0.18	1.37
The biology lecture(s)	174	1	1.37	-0.17	1.20
Biology instructors' ability to communicate information	174	1	1.34	-0.18	1.17
Biology instructors' helpfulness	172	1	1.29	-0.13	1.16
Biology instructors' ability to teach	174	1	1.35	-0.22	1.13
Biology instructors' attitude towards me	171	1	1.11	-0.11	1.00
Biology TAs' biology content knowledge	173	1	1.12	-0.12	0.99
Biology TAs' helpfulness	171	1	1.14	-0.15	0.99
The biology laboratory course(s)	166	1	1.27	-0.31	0.96
Biology instructors' attitude towards students in general	171	1	1.08	-0.17	0.91
Advisors' ability to help me choose courses	167	1	1.13	-0.28	0.85

Table 4.29: Aspects of the Major that Switchers Reported as Negatively Affecting their Overall Opinion of the Biology Major (Negative Effect Score > 1; Proportion reporting as no effect < 1/3; in descending total score order)

	N	M	Negative Effect	Positive Effect	Total Effect
The degree to which my biology grades reflected my understanding of the material	95	-1	-1.19	0.25	-0.94
The biology exams	96	-1	-1.17	0.28	-0.89
My grades in biology course(s)	97	-1	-1.24	0.38	-0.86

Perceptions of the College Biology Experience: Qualitative Results

Though not reported in this analysis, based upon interviews, persisters and switchers had very similar complaints about different aspects of the biology major, including but not limited to: poor teaching in calculus and particularly physics courses,

the disparity between the amount of work done and the amount of credit received in two-hour laboratory courses, disliking the lecture format of most science courses, and poor experiences with teaching assistants. While each of these complaints could be found in Seymour and Hewitt's (1997) "Problem Iceberg," because none of these difficulties was relevant to participants' decisions about their major (i.e. no one left biology because their TA was an English language learner) and because participants varied greatly in the types and level of experiences they had in general (i.e. most of the switchers and a few of the persisters had not taken physics), I decided to exclude this information from the data set. Instead, I chose the parts of the experience that were common among all persisters and switchers: their first year science experiences (this section) and their experiences with college biology personnel, namely advisors, instructors and peers (the next section).

Like the high school science experiences (Table 4.8), I classified the life story participants' college science experiences as being positive, negative, or unremarkable (i.e. "It was another lecture course."). Like those from high school, I combined negative and unremarkable responses because they had a similar effect, disinterest in all or part of the discipline. Since fewer participants had taken sophomore level genetics, physics, and organic chemistry, either because they had already left the major by that point or because they were taking courses out of traditional sequence, and in light of the survival statistics (reported later), I only looked at the courses that the majority had taken during their first year of college as a biology major, namely two semesters each of introductory biology and introductory chemistry. That so many of the persisters' "favorite" biology courses were upper-division and so few of the switchers had taken upper-division courses prior to switching is quite telling.

As outlined in Table 4.30, switchers and persisters had opposite experiences in introductory biology, with the majority of persisters reporting that they had positive

experiences and the majority of switchers reporting that they had negative or unremarkable experiences, particularly during the first semester.

Table 4.30: First Year Science Experiences of Life Story Interview Participants (n=16)

Course	N (P)	Count	Persister Frequency Effect Size	N (S)	Count	Switcher Frequency Effect Size
Positive 1st Semester Biology	6*	5	0.833	8*	1	0.125
Positive 2nd Semester Biology	6	5	0.833	5†	2	0.400
Positive 1st Semester Chemistry	7	3	0.428	9	2	0.222
Positive 2nd Semester Chemistry	7	3	0.428	8‡	2	0.250

* One switcher and one persister tested out of introductory biology.
† Three switchers did not take the second semester of biology.
‡ One switcher did not take the second semester of chemistry.

For example, one persister described of her experience, which she labeled her "best experience in college science":

> …it was a lot of fun because you always figured there's something more to what you're learning in high school and they can never really get into it, it'll just confuse you or something. [Biology] was like, "Okay, all the secret knowledge you didn't get before. Here it is!...Oh, that makes so much sense!" I loved that class.

While some of these descriptions mentioned the professor, the majority, as in the one above, centered on enjoyment of the material itself. Conversely, one switcher described his first semester experience as part of the reason he left the major:

> It was just reading the book and memorizing the important stuff, and you know, just writing it down on the exam. There wasn't much application and I guess that's also another reason why I left biology, 'cause it was mostly just memorization and I wanted something that, you know, that had some application to it…And then, the teachers were fine, I guess. Lectures got boring at times, but, you know…I guess too much biology would get boring.

Based upon these data, there appears to be an association between poor first semester biology experiences and eventual departure from the major. This is supported by the following pieces of evidence: 1) the switcher who reported having a positive biology experiences during her first semester persisted in the major for three years; 2) the

one persister who reported a negative biology experience his first semester actually left the major, only to return after taking and enjoying the second semester of biology; 3) the persister who reported a poor second semester experience had a good first semester experience; and 4) of the two switchers who reported positive second semester biology experiences, one eventually chose to minor in biology and the other used that as an indication she should continue on the pre-medical track with a different science major.

Similar to their experiences in high school, most of the persisters and switchers had negative or unremarkable experiences in their introductory chemistry courses, as another persister described of his experience:

> …I felt it was very easy. Again, sort of book learning. The professor tried to be engaging, but it's kind of hard if you have an audience basically, as a class…I felt like that's a normal science course. It wasn't bad. It wasn't great. It was just there. No hard feelings on that class.

Whether they described their chemistry course as mediocre, boring, or overwhelming, few participants had good things to say about their courses, as another switcher described of his course:

> …first couple of weeks, he's like, "All of the stuff" like general stoichiometry, blah, blah, blah, like "All of this stuff, you should remember from your high school…class," and…"This should be review for a lot of you." And a lot of kids were like… "Yeah, this is review" and I remember thinking the first week like, "I don't know any of this! This is not review. This is going really fast for me and…my chemistry class was when I was a sophomore in high school and I'm a freshman in college and that was what, almost three, two and a half years, ago?" …But, I remember thinking…"Chemistry and me do not mix." And I was just, you know, "Biology's great and I'm not doing that great in either, but it's something that I find way more exciting and I like a lot more. And chemistry's not my thing." So, I was just kind of overwhelmed I think by my first semester. It was kind of like, "How do I deal with not learning? I don't know how to learn…"

Interestingly all of the positive descriptions of chemistry experiences all involved enjoying the way the chemistry professor taught the course (i.e. hands-on demonstrations or enthusiasm), as one persister explained: "…he was real interested in teaching it and I

just keep thinking that the professor, if they like it, it makes the students like it. And I've really enjoyed both of his chemistry courses."

Perceptions of College Biology Personnel: Quantitative Results

Tables 4.31 and 4.32 present the college persons who encouraged persisters' and switchers' interest in biology, respectively. In both cases, biology advisors were the least encouraging. College teachers were rated as most encouraging by persisters and less so by switchers.

Table 4.31: College Persons Who Encouraged or Discouraged Persisters' Interest in Biology (in descending total score order)

Source (-3 Greatly Discouraged to Greatly Encouraged +3)	N	M	Encouragement Score	Discouragement Score	Total Score
College Biology Teachers	206	2	1.89	-0.12	1.77
College Friend(s)	202	1	1.35	-0.09	1.25
College Biology TAs	204	1	1.15	-0.08	1.07
College Biology Advisors	201	0	0.83	-0.20	0.63

Table 4.32: College Persons Who Encouraged or Discouraged Switchers' Interest in Biology (in descending total score order)

Source (-3 Greatly Discouraged to Greatly Encouraged +3)	N	M	Encouragement Score	Discouragement Score	Total Score
College Friend(s)	107	1	1.05	-0.08	0.96
College Biology Teachers	107	0	0.85	-0.54	0.31
College Biology TAs	108	0	0.56	-0.40	0.16
College Biology Advisors	104	0	0.38	-0.46	-0.09

As shown in Table 4.33, Mann-Whitney comparison of the persisters' and switchers' sources of encouragement revealed that persisters rated all college persons as more encouraging than switchers did.

Table 4.33: Comparison of Persisters' (P) and Switchers' (S) Sources of Encouragement and Discouragement during College ($p<0.05$, in descending effect size order)

Source (-3 Greatly Discouraged to Greatly Encouraged +3)	M (P)	N (P)	M (S)	N (S)	M-W U	Z	Sig. (2-tailed)	Effect Size r
College Biology Teachers	2	206	0	107	5426	-7.553	0.000	0.427
College Biology TAs	1	204	0	108	6972.5	-5.536	0.000	0.313
College Biology Advisors (P>S)	0	201	0	104	7263	-4.619	0.000	0.265
College Friend(s) (P>S)	1	202	1	107	9304	-2.067	0.039§	0.118

§ Exceeds Bonferroni-corrected p-value of 0.0033

In light of these and previously reported results, to determine the relative importance of college and precollege experiences, I added the scores into groups defined by different temporal periods: before high school; during high school; family (continuous); and during college.[39] Median scores (Table 4.34) show that, for both switchers and persisters, family was most encouraging, followed by high school personnel and then pre-high school personnel. This supports the importance of family and high school experiences in developing students' interests in biology, as detailed in the precollege experiences section. Mann-Whitney comparisons of group scores demonstrated that college personnel were most encouraging of persisters' interest in biology, and least encouraging of switchers' interest in biology, and that pre-high school personnel had minimal effect on both groups. These results support the previously mentioned qualitative finding that early academic experiences were less important in developing students' interest in biology and, as will be reported in the next section, that switchers and persisters have very different perceptions of their biology education, including faculty, advisors, and peers.

[39] Before High School = ES Teacher + MS Teacher + ES/MS Counselor/Principal + Childhood Friends;
During High School = HS Biology Teacher + HS Counselor/Principal + HS Friends;
Family = Mother + Father + Siblings + Other Adult/Family Member
During College = Biology Teachers + Biology TAs + Biology Advisors + College Friends

Table 4.34: Comparison of Persisters' (P) and Switchers' (S) Sources of Total Encouragement and Discouragement Grouped by Time and Location

Source	M (P)	N (P)	M (S)	N (S)	M-W U	Z	Sig. (2-tailed)	Effect Size r
Before High School	1	188	2	102	9132	-0.680	0.498	0.040
During High School	3	193	3	105	10124.5	-0.011	0.992	0.001
Family (continuous)	6	170	5	97	7079.5	-1.930	0.057	0.118
During College	5	199	1	102	5069	-7.131	0.000	0.411

Perceptions of College Biology Personnel: Qualitative Results

Similar to their descriptions of their precollege experiences, participants' stories of college experiences were very person-centered. Regardless of their eventual major, each participant discussed their experiences with biology personnel, namely advisors, faculty and peers. This next section describes participants' perceptions of each group of people, with special attention to differences between switchers and persisters.

Perceptions of Biology Advisors

During the life story interviews, I asked the participants to tell me about their advising experiences while in the biology major. Due to differences in their advising experiences, including the frequency of contact with advisors, the reasons they sought advisors (i.e. mandatory advising for registration, questions about courses or the major, or academic difficulties), and the types of advisors with which they had contact (biology, cohort advisors, natural sciences, or health professions), I coded their responses in two ways. First, I coded each participant's response as either containing references to positive experiences, negative experience, or both positive and negative experiences (Table 4.35). Secondly, I coded each description based upon emergent sub-themes (Table 4.36). The rationale behind this coding scheme was to simultaneously weigh each participant's experience equally and still account for individual experiences, rather than bias the results in favor of those who spent more time in the major.

Table 4.35 presents the counts of the experiences that switchers and persisters had with advising staff. Although the majority of both persisters and switchers included descriptions of negative experiences, persisters were far more likely to mention positive experiences in addition to negative ones. This is not necessarily because persisters had more advising experiences than switchers, thereby increasing the likelihood of having a good experience later, since three of the six switchers who had solely negative experiences stayed in the biology major for more than two years. In all, of the eight participants reportedly having positive experiences with advisors, over half also reported having negative experiences with advisors. All persisters' negative advising experiences occurred during the first year of college and positive ones occurred in subsequent years.

Table 4.35: Advising Experiences of Persisters (P) and Switchers (S)

Type of Advising Experiences	Count (P)	Persister Frequency Effect Size	Count	Switcher Frequency Effect Size
Positive Advising Experiences Only	2	0.286	1	0.125
Both Positive and Negative Experiences	4	0.571	1	0.125
Negative Advising Experiences Only	1	0.143	6	0.750
Total	7	1.000	8*	1.000

* One switcher never sought advising

Table 4.36 presents the counts of participants' perceptions of their advising experiences, including exemplary quotes describing each. The most prevalent complaint from both groups was that advisors offered generic advice, typically in the form of the prescriptive coursework listed on the degree plan, or what "most biology majors" take. The only obvious differences between persisters and switchers were that persisters were more likely to describe that they felt advisors were helpful and switchers were more likely to report that they felt advisors treated them like a number. This latter perception often referenced the large number of students in the biology major. While both switchers and persisters (in life story interviews and focus groups) mentioned difficulties dealing

with the size of the university or their courses (mostly physics and chemistry), at an approximately equal rate (6 of 16 switchers and 7 of 19 persisters), switchers were the only ones to mention size with respect to advising. Whether this is due to comparatively different experiences in their new major is unknown, since a couple had not received advising in their new major at the time of the interview.

Table 4.36: Persisters' and Switchers' Perceptions of Biology Advising Experiences

Perception of Advisors	Persister Frequency Effect Size	Switcher Frequency Effect Size	Exemplary Quote
Helped Me	0.714	0.250	…every time I would go to an advisor, you know, they would offer me all the options that I had about the classes to take and also offer recommendations …because…a lot of students come to them with complaints or with… compliments about teachers, they could also advise you and tell you…which teachers you would enjoy more, which professors classes you would enjoy more.
Offered Generic Advice	0.571	0.625	I always felt that I was…just being processed, you know? Like choosing classes was me going in there and her saying, "Okay, here's the classes you need to take. This is the next thing that most biology majors do, and so therefore you need to do it."
Treated Me Like a Number	0.000	0.625	You walk into their office, they sit you down…they pull up your screen of classes, they write down your classes that you know you're taking…and they hand you this piece of paper…with the scheduled little blocks and say "Well, here," you know, "I think this is good to register for." And they just read you what you've chosen yourself…And then, within five minutes, her screen is dinging again and there's somebody else waiting …It's like they hand you this and you're expected to be done. And if you keep asking questions, they make you feel like [sighs] "I have another student waiting." Well, it's like, "Hey, I just scheduled an appointment. Why don't you schedule it longer than five minutes?"…

Perception of Advisors	Persister Frequency Effect Size	Switcher Frequency Effect Size	Exemplary Quote
Gave Incorrect Information or Lacked Knowledge	0.286	0.375	…I'm in this physics class now and, it turns out, it's the wrong physics class 'cause this biology advisor gave me the wrong class. It's like…"Come on, just give me the right information here."
Advised Me to Reconsider or Change Major	0.143	0.250	…[my advisor] told me I was wasting my time at one point in time…"She's like, what are you doing? You're supposed to be concentrating on graduating as quickly as possible, that way you can apply to med school and have like chances to reapply and a linguistics major is really gonna slow you down." It's like, "Oh."

Perceptions of Biology Faculty

During both life story and focus group interviews, participants described their interactions with faculty. This section begins with a description of the emergent sub-themes from both life story and focus group interviews that illustrate participants' perceptions of instructors, a comparison of switcher and persister perceptions of their instructors, and exemplary quotes describing each theme. Interestingly, all of the sub-themes fell into natural dichotomies, largely based upon the words used by the participants themselves. Table 4.37 presents each pair of themes and its definition as summarized from participant responses, beginning with the code with positive connotations. As reported in both life story and focus group interviews, switchers and persisters had different and sometimes opposite perceptions of biology faculty,[40] and in a few cases, persisters and switchers even had opposite perceptions of the same faculty member. Table 4.38 presents the counts and frequency effect sizes of each of the above categories, emerging from persister and switcher descriptions. Table 4.39 presents exemplary quotes for each code listed.

[40] Although several participants mentioned teaching assistants in addition to faculty, these statements were excluded from analysis because, in about half of the cases, the participant could not remember which course or even discipline the TA taught or the in comments referred to generalizations about TAs

Table 4.37: Dichotomous Themes Describing Interview Participants' Perceptions of Biology Faculty

Dichotomous Themes	Description
Challenging – Exacting	In the context of assessments and grading, faculty were viewed as having high or challenging standards which (usually in retrospect) helped the participant in some way OR as having unrealistic or oppressive standards which frustrated the participant
Caring – Indifferent	In the context of their interactions with the student, faculty were viewed as caring OR not caring about the participant's needs, progress or learning
Engaging – Uninspiring	In the context of their teaching style or methods, faculty were viewed as being enthusiastic or engaging students in the material, OR as being boring or turning students off to the material
Welcoming – Unwelcoming	In the context of interactions with participants, faculty were viewed as being open OR closed to questions; welcoming OR unwelcoming of students during office hours.
Student-interested – Self-interested	In the context of the teaching – research dichotomy, faculty were viewed as being more interested in teaching and helping students OR being more interested in their own research.
Knowledgeable – Incompetent	In the context of content knowledge, faculty were viewed as knowing OR not knowing the subject well; able OR unable to organize and communicate information effectively.

Table 4.38: Persister (n=19) and Switcher (n=16) Perceptions of Biology Faculty (in descending frequency effect size order)

Persister Perception	Persister Frequency Effect Size	Switcher Perception	Switcher Frequency Effect Size
Challenging	0.526	Indifferent	0.750
Engaging	0.421	Unwelcoming	0.500
Caring	0.368	Uninspiring	0.438
Welcoming	0.368	Exacting	0.313
Self-interested	0.263	Caring	0.250
Indifferent	0.157	Self-interested	0.250
Uninspiring	0.157	Engaging	0.125
Exacting	0.105	Welcoming	0.125
Incompetent	0.105	Challenging	0.063
Knowledgeable	0.105	Incompetent	0.000
Student-interested	0.105	Knowledgeable	0.000
Unwelcoming	0.105	Student-interested	0.000

There are three generalizations that can be gleaned from this data presented in Table 4.38. First, switchers and persisters had, in most cases, almost opposing perceptions of biology faculty, with the four most prevalent of persisters' descriptions of biology faculty being positive in connotation and the four most prevalent of switcher descriptions of biology faculty being negative in connotation. Second, although all of the persisters had an overall good opinion of biology faculty as a group, the fact that less than half included descriptions of faculty as being engaging, caring, welcoming, knowledgeable, or student-interested indicates that these characteristics were the exception, rather than the rule. Demonstrating this further is that when either switchers or persisters described these positive traits, they were attributed to a specific faculty member, and rarely voiced as generalizations describing the average faculty member or most faculty members. Third, while only two of the sixteen switchers and one of the nineteen persisters directly attributed their experiences with faculty as part of their departure/persistence decision, it is evident based upon these data, that there must be some association between having negative perceptions of faculty and leaving the biology major, and having positive perceptions of faculty and staying in the biology major.

Table 4.39: Exemplary Quotes of Participants' Perceptions of Biology Faculty (continued on next pages)

Perception of Faculty	Exemplary Quote
Challenging	…it was really funny because she only give like 10% A's something crazy and she really wasn't that bad…And I just loved her class so much and she really taught it well. She made you understand it…you couldn't really memorize things, you had to like learn it and then you had to apply it 'cause her tests were all application…
Exacting	…she would want exact phrases that she used in class. She wouldn't accept substitute words in the blanks and most of her exam was full of blanks, you know, instead of what she wanted you to put in the blanks…Her exams were also like really long and I don't know if anyone was able to finish them, but I wasn't. It seemed like we had, you know, 50 minutes to finish an hour and a half exam. There was a lot of writing, so it was really hard to finish.

Perception of Faculty	Exemplary Quote
Caring	She just astounded me that her class was so enormous. All her classes were so enormous and yet, she knew my name at the end of first semester. And, it wasn't just my name…she knew almost everyone's names. And she was very interested in talking to us about things. She had office hours all the time…And, I felt like, having that kind of a professor to start off in college, was so encouraging because it made me feel like, "Okay, I'm probably gonna have professors that don't care this much, but right now, when I need it the most, this woman actually cares about…how I'm doing in her class, and how everyone's doing in her class. And she really cares about us getting the material and understanding the material and doing well on exams."
Indifferent	I guess I kind of felt like…like the instructor didn't really care about how we did…I didn't really see anyone that was like, "Oh my gosh, I made an A!" You know, everyone was like, you know, "Man, I can't believe I did this bad" you know? And I just thought, you know, maybe that she would've seen, "Okay, they're all doing not so great," you know, "What's going on here? What's wrong?"
Engaging	And I loved my class with [her]…everything she would talk about, she was so excited about it and it was just great and I loved the way she taught.
Uninspiring	Monotone and just like, "This and that. Blah, blah, blah, blah, blah, blah, blah, blah, blah. Go home. Read the textbook." "Wow, that's great."
Welcoming	I think students like to be treated as…like, not the same level, they're not the same level, but just like at a respected level, you know?...I'm sure I or anybody else has asked like a dumb question or like something that you were expected…or you could find in the book or whatever, and she answers it…Maybe you didn't spend as much time on the book as you needed to, but it doesn't matter, they still want you to know the information, and so they're just really treating you as like someone who wants to learn the information as much as they do.
Unwelcoming	I went into his office hours one time…to ask some questions and to talk about a test and stuff like that and…was almost like forced out the door…It was during his office hours and he didn't want me to be there, you know, he was angry that I was there…He looked up and was like, "[sighs]." I was like, "This is your office hours, what are you talking about man?" And…he made [grading] mistake[s] on one of the tests…and one time he corrected it and one time he didn't. And the time he did, he acted like he was doing me a favor or something, you know? And I don't think I was being overly sensitive, you know? I just think he just wasn't very nice…

Perception of Faculty	Exemplary Quote
Student-Interested	I love them…it's so great to see people teach that actually care about what they're teaching about, and I think that was just the most wonderful thing, to see people who were really into biology, doing what they care about…And…as soon as they get to the part that they're really into, they're just like, "Oh, this is so great!" and they're like drawing on the board and they're like, "And you see? This is why it's important because…"…When people really get into something they care about, their eyes like light up and so, I think that's the greatest thing ever, to be [teaching] for the right reasons.
Self-Interested	…she kept telling us she didn't wanna be here, she didn't wanna teach, and the only reason she was teaching genetics is 'cause they made her …if you were at the university, you had to teach at least one course and she's really only here for the research. And so I felt like…she didn't really want us and she didn't wanna write any letters of recommendation. She's like "Don't ask unless you get like a 90, 99, or something in this class." So, that was really discouraging…
Knowledgeable	I definitely feel like all of my biology instructors, even the bad ones, know a lot about biology. That's never really an issue, for the most part. Any questions I've ever asked, it seems like they could give a pretty good answer.
Incompetent	…he really wasn't a good teacher because he'd make these mistakes like on the subject and he was so slow. We were like still on chapter two while…all the other classes were on chapter five. He'd make mistakes with certain details, like I can't really remember the specifics but like our TAs would basically teach us the class, not him. And so, no one went to class and it was a horrible experience.

Perceptions of Classmates

When life story and focus group interview participants spoke of their peers, four sub-themes emerged: competition with or because of classmates; friendships with other biology majors; and involvement in cohort groups. While these themes do not necessarily represent peer interactions indicative of staying in or leaving the major, there are generalizations that can be gleaned from the relative proportions of switchers and persisters who reported negative or positive experiences with their peers.

Competition. Competition among students for grades, particularly as instigated by premedical students, figured prominently in participants' descriptions of their peers. While both persisters and switchers were bothered by competition, persisters, including

those classified as premed, complained about competition more than switchers (12 out of 19 persisters versus 7 out of 16 switchers). Whether this is due to their greater length of time in the major or a greater commitment to biology requirements than premed requirements is up for speculation, since the majority of both groups of participants were, at one point, classified as premed. Furthermore, persisters were far more likely to attribute competitive behavior to premed students (10 out of 12), while switchers were more likely to attribute competitive behavior to "other students" (5 out of 6). Because of this, there is a possibility that these switchers may have mistakenly attributed what persisters regarded as an odious premed trait to the average biology student.

Participants had a variety of descriptions of what they labeled as competition, ranging from the irritating (being asked about test grades by strangers) to the abhorrent (being purposely given wrong information in a study group). More importantly, however, they described the effects of this competition on how they felt about the major and their peers. Exemplary quotes describing the various effects of competition are described in Table 4.40. The commonality among these stories was that this competition involved feelings of separateness, with each participant either not feeling part of the group, avoiding being part of the group, or aspiring to be part of the group. Also noteworthy in this data is, although competition seemed to affect persisters and switchers in similar ways, switchers gave more examples of feeling inadequate and feeling excluded, whereas persisters gave more examples of leaving the situation altogether.

Table 4.40: Exemplary Quotes Describing the Effects of Competition (in descending frequency effect size order, continued on next page)

Effect of Competition	Persister Frequency Effect Size (out of 12)	Switcher Frequency Effect Size (out of 7)	Exemplary Quote
Feelings of Inadequacy	0.333	0.714	The grades…like when they saw your grade and they ask you, "Hey, what did you get?"… and I wouldn't have good grades and so it would kind of be like, "Uh, I failed." They're like, "Oh." "What did you get?" "Oh, I got a 90."…It would make me feel awful, like I wasn't smart enough, and I knew I could do it, I just didn't…know what I was missing.
Feelings of Exclusion	0.167	0.429	…people that lived around me and with me and just people in my classes didn't wanna study together because…they were stingy about stuff…You'd be like, "Hey, did you understand this?" or "Do you wanna get together later or something?" I don't know, I just always felt like I was their competition for medical school and I'd always try to explain that that wasn't a goal of mine and [they thought] I was probably a big slacker…
Getting off of the Premedical Track	0.333	0.286	…once I saw this huge competitiveness 'cause that's what a lot of other students, the competitive students in my classes were going for. And I said, "I don't like that at all. I don't like that environment. I don't like people…backstabbing other people," you know? There's some good people out there. Yeah, they mean well, but there's too many of the bad ones that ruined my idea of going to medical school.
Not Participating in Organizations or Biology Department Functions	0.250	0.000	…'cause my first couple of semesters here, I was like trying to get into the groups and stuff and it's so competitive and annoying that, since then, like I will go to no biology function. I'll go to no biology anything 'cause I hate the people. I'm sorry. I hate the people that are just like premed and like pre-everything and they're so competitive and they don't think for themselves and all they care about is their grades. I'm done with that…

Effect of Competition	Persister Frequency Effect Size (out of 12)	Switcher Frequency Effect Size (out of 7)	Exemplary Quote
Inspired to do Better	0.083	0.000	…just seeing them like get these grades…it makes me think like, you know, I can do that, I guess eventually. So, I think, not really in the sense that I enjoy being competitive with other students. I don't mean [that] I like the fact that, like a lot of times, most people get C's or B's and hardly anybody gets A's. I don't really like that…but, you know, I think I enjoy the fact that there's people that know it really well and it kind of encourages me to get to that point. It's more of like an incentive like, "You could do this if you tried."

Peer Relationships. Another theme that emerged from interviews was the importance of peer relationships. Participants described three different, sometimes overlapping peer relationships in the biology major: friendships, partnerships, and comradeships. Friendships involved peers socializing with each other; partnerships involved peers studying together; and comradeships involved peers identifying with each other. Table 4.41 presents these relationships, frequency effect sizes and exemplary quotes. Although many of the participants mentioned their friends or classmates (i.e. "My biology friends and I…"), I only coded detailed descriptions of how the participant interacted with their peers. Interestingly, switchers were more likely to make distinctions between friends and study partners than persisters, whereby only one of the switchers, but all of the persisters who mentioned partnerships described studying with "friends." Lastly, as evident in the table below, there is a predominance of both friendship and comradeship among persisters as compared to switchers.

Table 4.41: Peer Relationships among Biology Students Described in Interviews (in decreasing frequency effect size order)

Peer Relationship	Persister Frequency Effect Size	Switcher Frequency Effect Size	Exemplary Quote
Partnership	0.316	0.438	…I did a lot of studying with other people, even if we didn't talk, we still sat together at least…So, if you had a question, you could always ask someone else, rather than try and figure it out yourself for hours.
Friendship	0.421	0.125	…the fact that I have these two girls who have the same…beliefs as I do, the same values as I do, and that I can have tons of fun with. I think having them helps me keep everything in balance, I guess.
Comradeship	0.263	0.000	Like you sit in there and you hear all these people talk, but then you look at the people sitting next to you and they're like just as lost as you are. And you're like, "Yes! I know exactly how you feel."…Or I'm sitting in, whatever class, and they're all just like, "I don't know what's going on." And you just laugh about it a little bit and they you still don't know what's going on, but it makes it easier.

Cohort Groups. The last emergent theme involving peer relationships were those formed as part of a cohort group. A cohort group is a small group of students who are concurrently enrolled in the same two to four courses and may live in the same dorm as well. Four of the persisters and five of the switchers described their experiences with the cohort group. Table 4.42 presents subthemes, frequency effect sizes and exemplary quotes describing participants' perceptions of cohort groups. While less than a third of the participants mentioned cohort group involvement, there appeared to be an association between doing well in courses, liking the cohort group experience, and staying in the major; and doing poorly in courses, not liking the cohort group experience, and leaving the major.

Table 4.42: Exemplary Quotes Describing the Cohort Groups (in descending frequency effect size order)

Perception	Persisters (out of 4)	Switchers (out of 5)	Exemplary Quote
Access to Study Partners	3	1	Just 'cause…learning the way they study, or like sometimes if I don't think of a question, then that would be something that they would raise …because I was in [the program], I think all my discussion sections were with people that I kind of knew of, at least initially, my freshman year. So, I really enjoy like bouncing things off of them and studying with them.
Making Friends	2	2	I made a lot of friends my first year 'cause all my classes I had with the same people 'cause I was in [the program].
Not Fitting Into the Group	0	2	I didn't really connect with anybody there, just the group of people. It seemed like everyone that was there, they already knew each other, like there was already groups there…and I felt like I kinda didn't really fit in.
Feeling Excluded from the Group	0	2	It was hard to study with them, try to get into their group, 'cause they've already formed cliques and stuff inside of [the program…]. They just had that arrogant…thing. They would never invite me…or invite other people…it wasn't warm to be around. They would just give me the cold shoulder a lot of times…if I could go back, I wish I didn't do [the program].
Liked the Smaller Size	1	1	The freshman year science classes are so huge that I think that, had I not been in [the program], I would have felt a lot…smaller. I would have, I think, been a little more intimidated by the size of the class.
Disliked the Smaller Size	1	0	I was in [the program] and…you're still in high school, like you deal with the same people everyday, every class…And they know all your stuff, you know? They know how you did in your last class and you don't want the past being brought up and dangled in front of you.

While almost all of these participants enjoyed some aspect of their cohort group, such as the smaller group environment, the ease of meeting people, or the ease of finding study partners, four of the five switchers mentioned feelings of not fitting in or even feeling excluded from the cohort group, largely based upon what they perceived as

comparatively poorer performance in their courses. While none reported that their experiences in the cohort group caused them to leave the major, three did explain they left the major, in part, because they did not fit in the biology major (as discussed later). The other reported that she left due to comparatively poorer grades in her courses, but was turned away from the medical field due to the competitiveness she saw within her cohort group. Interestingly, all of the descriptions of cohort groups in this study came from female participants. Although three of the 13 male participants were involved in cohort programs, none of them mentioned it during the interview (except to name the group itself). Furthermore, male participants had little to say about their peer relationships in comparison to female participants with less than half (6 out of 13) of males and all of the female participants mentioning any kind of peer relationship.

THE PHENOMENON OF STAYING

To provide a more inclusive picture of the phenomenon of staying in the biology major, it was not only important to describe why students stay in the major, but also which students were likely to complete a biology degree in terms of their personal and academic demographic characteristics. This next section begins with the larger description of biology graduates and concludes with both quantitative and qualitative results concerning persisters' reasons for staying in the biology major.

Who is Graduating with a Biology Degree?

As mentioned in the introduction, and reported in Table 4.43, analysis of 1389 biology students who graduated between December 2003 and August 2006 (College of Natural Sciences, 2006b) revealed that 58.0% of the students who received biology degrees began their freshman year as biology majors, with approximately 30.2% of biology graduates originating in other STEM colleges and only 11.8% of biology

graduates originating in non-STEM colleges. Removing the 332 undeclared students from this analysis further demonstrates the poor draw of biology among those initially interested enough in a discipline to choose a major, with 76.2% of biology graduates starting out in the biology major; 18.4% of biology graduates starting out in other STEM majors; and 5.4% of biology graduates starting out in non-STEM majors.

Table 4.43: Original Majors among Biology Graduates, A.Y.[41] 2003-2006

Original College Major	Frequency	Percent
Biology	805	58.0
Business*	22	1.6
Education	4	0.3
Engineering	78	5.6
Fine Arts	5	0.4
Social Work	2	0.1
Architecture	2	0.1
Communication	7	0.5
Liberal Arts*	122	8.8
Natural Sciences,* Other	328	23.6
Nursing	14	1.0
Total	1389	100.0

*Undeclared included

In terms of gender, 60.8% of biology graduates from A.Y. 2003 through 2006 were female and 39.2% were male. This is not significantly different from the percentages of males and females entering the biology major as reported earlier (x^2= 0.30, p=0.584). Moreover, even though this is quite different from the entire pool of graduates of The University in the same years, 53.2% female and 46.8% male (Office of Institutional Research, 2004a; 2005; 2006), it is not significantly different from those percentages (x^2=2.03, df=1, p=0.154). In terms of generation, 86.5% of biology graduates from A.Y. 2003 through 2006 were traditional college students and 13.5% were first generation college students. This too was not significantly different from those entering the biology major reported earlier (x^2=0.03, df=1, p=0.863).

[41] Academic Year

The ethnicities represented among biology graduates from A.Y. 2003 through 2006 were significantly different than those represented among biology freshmen due to a decreased proportion of White students and an increased proportion of Asian-American students graduating with a biology degree (x^2=11.21, df=1, p<0.001). As seen in Tables 4.44 and 4.45, this was also the case when comparing biology graduates to the entire pool of graduates the same year. There was no significant difference between the proportion of African-American or Latino students among biology freshman or graduates (x^2=3.760, df = 1, p=0.153) or between the proportions of biology graduates and the entire pool of graduates the same years (x^2=0.642, df=1, p=0.423).

Table 4.44: Ethnicities Represented among Biology Graduates, A.Y. 2003-2006

		Frequency	Percent	Valid Percent
White		671	48.3	48.7
Native American		4	0.3	0.3
African-American		40	2.9	2.9
Asian-American		480	34.6	34.8
Latino/Hispanic		183	13.2	13.3
Total		1378	99.2	100.0
Missing	Unknown, Foreign	11	0.8	
Total (≠ 100% due to rounding)		1389	100.1	

Table 4.45: Ethnicities Represented among All Graduates, A.Y. 2003-2006 (Source: Office of Institutional Research, 2004; 2005a; 2006)

		Frequency	Percent	Valid Percent
White		16566	62.4	65.0
Native American		89	0.3	0.4
African-American		862	3.2	3.4
Asian-American		4530	17.1	17.7
Latino/Hispanic		3442	13.0	13.5
Total		25489	96.0	100.0
Missing	Unknown, Foreign	1053	4.0	
Total		26542	100.0	

In terms of advising area, 62.5% of biology graduates were classified as health professions (HP) and 37.5% of biology graduates classified as none or other (non-HP). This is not only significantly different from the classifications of biology freshmen (x^2=45.68, p<0.001), it is the exact opposite (recall that 30.8% of biology freshmen were health professions and 69.2% are none or other). The fact that many switch-ins from other majors follow this trend (Table 4.46) implies that the major draw into the biology major, particularly from non-STEM majors, is future employment as a physician or in other health professions.

Table 4.46: Comparison of Initial and Final Advising Area by Major

Initial Major	Initial Area Percent		Final Area Percent		x^2	Sig.
	Non-HP	HP	Non-HP	HP		
Biology	65.0	35.0	35.4	64.6	37.22	p<0.001
Other STEM	63.1	36.9	37.9	62.1	26.20	p<0.001
Non-STEM	95.1	4.9	47.0	53.0	486.23	p<0.001

Lastly, in terms of degree conferred, 43.8% of biology graduates earn a Bachelor of Arts degree and 56.2% of biology graduates earn a Bachelor of Science degree. This is not significantly different from the degrees initially sought by biology freshmen (x^2=0.02, p=0.888).

Reasons for Staying: Quantitative Results

Table 4.47 presents the reasons most reported by persisters for staying in the biology major, with the top two reasons concern persisters' enjoyment and interest in biology and that the majority of reasons concern the same (marked with minuses). Also prominent in these results are suitability of or fit with biology (biology is right for me, my talents are best suited, I belong or fit in) as important reasons for staying in the major (marked with exes). Five of the items concerned persisters' perceptions of performance (marked with asterisks) and three concerned career pursuits (marked with pluses).

Table 4.47: Top Reasons Persisters' (N=190) Reported Staying in the Biology Major (proportion > 0.50; in descending score order)

Reasons (3 Moderately True of Me to Completely True of Me 5)	M	Score	Prop.
I am still interested in biology -	5	3.95	0.90
I still like biology -	4	3.94	0.91
I am still interested in a career or profession for which a biology degree is helpful or required +	4	3.76	0.84
I like my biology courses -	4	3.40	0.82
A biology degree will best prepare me for what I want to do after college+	4	3.39	0.78
I feel that biology is right for me x	4	3.38	0.80
I feel that I belong or fit in the biology major x	4	3.22	0.79
I prefer biology over other disciplines -	4	3.19	0.75
I like the learning experiences that my biology courses have provided	4	3.08	0.76
I feel that I can succeed in biology*	4	3.04	0.74
I am more interested in my biology courses than my other courses -	4	3.02	0.76
I have not changed my mind about what I want to do after college +	3	2.80	0.66
My talents are best suited to biology x	3	2.63	0.68
I perform well in biology*	3	2.57	0.67
I need to major in biology to prepare for or enter my chosen career +	3	2.49	0.63
I have learned more in my biology courses than in my other courses	3	2.43	0.65
I have a higher aptitude for biology than for other disciplines*	3	2.35	0.61
I do not have difficulty handling the pace of my biology courses*	3	2.16	0.58
I do not have difficulty handling the amount of information I am expected to learn in my biology courses*	3	1.97	0.53
I like the way my biology courses have been taught	3	1.93	0.54

Reasons for Staying: Qualitative Results

As shown in Table 4.48, the qualitative results for the most part echoed the quantitative results, with enjoyment and interest figuring in as two of the top reasons for staying in the major. The major difference was the prominence of statements indicating that the persister stayed in the biology major due to a desire to not give up or give into the rigors of the major. Each of the major responses (frequency effect size of 0.333 and greater) will be described in the next section. Exemplary quotes from the other types of responses can be found in Table 4.49.

Table 4.48: Reasons Persister Participants Reported Staying in the Biology Major, N=19 (in descending order of frequency effect size)

Persister Reasons for Staying Biology	Persister Frequency Effect Size
Not Wanting to Give Up or Give In	0.579
Enjoyment of Biology	0.526
Continued Interest in Biology	0.368
Good Performance in Biology	0.368
Particular Course Experience	0.368
Working in Biology	0.368
Not Interested in Other Options	0.316
Personal Encouragement	0.316
Friends/Feelings of Belonging	0.263
Liking Future Career Options	0.211
Liking the Challenge	0.211
Never Considered Leaving	0.211
Doing Important Work after Graduation	0.158
Double-majoring with a Non-Science Degree	0.158
Impressing Others	0.158
Did Not Take Science Freshman Year	0.105
Focus on a Career Connected to the Major	0.105
Not Disappointing Parents	0.105
Pursuing a BA rather than a BS in biology	0.105
Switching to Another Major	0.105
AP Credit for Introductory Biology	0.053
Better Preparation for Medical School	0.053

Not Giving up or Giving in

Based upon both interviews and focus groups, the most common reason persisters stayed in the major was their desire not to give up due to or give into the rigors of the biology major. In effect, these persisters did not decide to stay in the major; rather they chose not to leave. For a few, this was simply the desire to not be a quitter, as one persister explained: "The reason I stayed is if I leave, then that would be like I quit. You know, I couldn't handle it. I don't wanna feel that way…That, to me, is worse than like studying…" Others described their desire not to give up or give in as determination induced by the difficulties they experienced: "...I don't really want this major to have gotten the better of me. I guess I was kind of like too proud…I just started thinking

about, you know, 'If I could put a couple more hours into it, or something, I could probably get a better grade,' and you know, kind of just pushed myself that way."

In conjunction with not giving up due to the difficulties they experienced while a biology major, a few participants reported persisting for the sake of finishing a degree or graduating: "…well, my main reason has just kind of been keep going and wait for the finish line. I've kind of been…'You got three years left. You've got two years left. You've got one year left.'" This type of "stay the course" response was often accompanied with a description of the additional time it would take to graduate with a different degree: "If I did change majors, it would mean more than four years to graduate and…I don't like that thought, having to be in school longer than I have to and like wasting all that time." Others noted not the time, but the energy they would waste if they switched to an easier major: "…and if I left, I would've taken o-chem and genetics for no reason and…I'd kill myself for that."

Enjoyment of Biology

The next most-reported reason for staying in the biology major was enjoyment of biology courses or the discipline itself:

> Yeah, the number one thing that kept me going was the material. I just really liked it and I felt that it was exciting. And there was the potential for growth. Like new information was always coming in from, you know, experiments and things like that. So, it wasn't like other fields, like maybe literature or something, where you're probably dealing with the same literature all the time.

Noteworthy in participants' reported experience is that only three out of ten had significant experiences outside of the biology major (i.e. double majoring or switching out and back into biology), which means that a considerable portion of these participants may not have had the opportunity to enjoy anything but biology. Moreover, while it is not surprising that enjoyment is important for persistence in science, it is noteworthy that,

for five of the nineteen persisters, neither interest in (discussed later[42]) nor enjoyment of biology figured into their decision to continue in the major. In fact, when two of these individuals were pressed by other focus group participants whether they like biology, one replied: "I don't hate biology" and the other replied: "I hate the biology major. I love biology," in effect distinguishing between the major and the discipline itself.

Continued Interest in Biology

Several participants reported staying in the biology major due to their continued interest in their courses or the discipline itself: "…I guess, just the passion that I have for biology and the interest that I have in it. I think that if I stopped being interested in things I was learning, then I would reevaluate. But as long as I continue to leave my bio lectures feeling like, 'That was cool!' I think that I will continue to want to be a bio major." Similarly, another persister explained that she stayed in the major because of a desire to learn more: "…I get excited in learning how things work and structures of things and how that relates to other work and I just like learning about it…So, that keeps me in it. I'm like, 'Ooh, what's the next step? What's the next class that I get to think about this?'"

Good Performance in Biology Courses

Several persisters reportedly stayed in the major due to their good performance in biology courses. Some explained that their good grades gave them evidence that they should stay in the biology major: "And I'm making good grades. Like if I was making bad grades, I'd probably leave, but I make all good grades, so there's no reason." Others explained that they performed better in biology than in their other courses, often noting the role that interest played in their performance: "…I get better grades in bio than

[42] Interest and enjoyment were coded separately because not all those interested in biology reported liking biology and vice-versa.

anything else, even like stupid stuff. Like I took a mythology class and I was like, 'Oh, it will be stories, or whatever. It will be great,' and 'I read mythology. It's awesome.' And it was like, you know, memorizing pottery…Like I hated it so much." All of these persisters noted that their grades offered some sort of confirmation that they had chosen an appropriate major.

Particular Course Experience

Several persisters reported staying in the major due to a particular experience, either as part of a course or functions within their major:

> …I…had the opportunity to do like…a workshop for like CLS majors…Every semester, they have someone come in…and it was a hematology workshop and it was really, really cool…I haven't taken immunology or anything like that, so I really don't know much about the blood, but it's just learning cool stuff like that…I'll be sitting, looking at, "Oh, this is what leukemia looks like. Oh, this is what this looks like." You know, looking at that…it gives me more of a reason.

In a few cases, this experience came during a time in which the participant was contemplating a change of major or career:

> And then…the last night of the [field] trip, we had somehow gotten a case of beer and we were out in South Texas…And everyone else was sleeping and I was up drinking with some of these guys and, for pretty much the whole class, they had been kind of lazy and unresponsive and just bored. And I was like, "Guys, we should go look for these geckoes that live out here." And they were like, "Oh, all right. Let's do it." We could barely walk too. It was such a bad idea. And there were like tarantulas running around everywhere. There were scorpions under these rocks and stuff. And we were out from like midnight till three and I was ready to turn around after an hour, like we weren't finding anything except for tarantulas, which creep me out. But these guys were like, "No, let's keep going." So, they kept me out there until three, like they were just so excited and I was like, "Man, if I can make people this excited…I might be good at what I'm doing."

While both of the above represent special events in a class or major, there were a few students who in part, stayed in the major because of a traditional course experience:

> I guess [genetics] was my first upper division class, so first semester sophomore year. I loved that class. That was the greatest class that I've ever taken. She was

> just an amazing professor and…that class was really, really hard, like everyone was just like, "Oh God, don't take _____, you know, she's so hard." And then people that had a good experience in there would be like, "Oh, she's the best professor. You've got to study, but she's just really good," and I did well in there…I guess that was something to be proud of, you know? A lot of people were intimidated by that class and I did okay and I really, really liked it. It was one of the few classes that, you know, I'd like record lecture and I'd actually go home and listen to every one of them. Most classes I'd record it, but, you know, it'd be very rare if I went back and listened to the whole thing.

Noteworthy in all of these types of responses is that a single experience can be evidence a student has chosen the right major or should continue in (or not leave) their major.

Working in Biology

Lastly, several persisters reportedly stayed in the biology major due to their work in a biological field. Whether this was participating in research at school, doing internships elsewhere, or volunteering for non-profit conservation organizations, over one-third of persisters explained that these experiences gave them evidence that they should continue in the major: "So, then I got into a research lab and that sort of reinforced the fact that I was in this for the rest of the way." For some, their work cemented their interest in the discipline itself, as another persister explained:

> …I worked for a year at the _____ Zoo and I lived there for six months and I don't wanna be a zookeeper. I mean, being a zookeeper is like being a janitor, but for animals. Like you're just cleaning up after them and stuff. But, on the other hand, it was so like hands-on, like I did everything out there. I did primates, big cats, like the whole thing, and I lived there and so I was like out with the animals at night and like doing all this stuff. And I realized that I was incredibly under-qualified for it, so I had to do all this sort of research 'cause I'm taking care of these like really sensitive species, especially the primates. And I was the only person that did primates there for a long time…so I had to start learning about like the animals that we had and then getting to work with them and learning primate behavior, just hands-on, was like so cool. So, you know, even though I'm like a general biology major and that doesn't necessarily bleed into primatology or whatever, it's still science and it's still animal biology for me.

For others, working in the field confirmed not only their choice of major, but their choice of profession as well, as one persister explained:

> Working in [his] lab was…I knew right off the bat that I was doing the right thing. And then when he invited me to go to Indonesia and do fieldwork, you know I knew that that was a really good opportunity. But then when I got there, you're working 20 hour days and you're exhausted and "Man, what are we doing?" and then like, you see a frog and you grab it and you like look at it and think, "Holy shit. This is a new species!" I mean, that's just like a rush, you know?

For each of these persisters, working in the field translated into not only making biology real, but also personalizing it in some way, as another persister explained: "It's just a lot more important to me that I'm doing my own research than like just being in class."

As mentioned previously Table 4.49 presents exemplary quotes describing the remaining sub-themes concerning persisters' reasons for staying in the biology major.

Table 4.49: Exemplary Quotes Describing Persisters' Other Reasons for Staying in the Biology Major (continued on next pages)

Reason	Exemplary Quote
Not Interested in Other Options	It's 'cause I was like, "Okay, this is hard, but what else would I do?" And I'd think about it and there's nothing else that really interests me that I'd want to take 100 more [hours] of.
Friends/Feelings of Belonging	…I consider myself like a bio nerd, like I make bio jokes. My friends and I will make bio jokes or chem jokes and like, we think it's really funny…And I think, having those friends kind of makes me feel like I belong more. If I didn't have those friends…I'm sure that in any major, you're gonna find people that you're close to, some people you can relate with, but I think that since we're so close and so similar and have such similar passion for bio, it makes me feel like, "Well that must be what these other bio majors that I'm not really close to, they must be this way also."
Personal Encouragement	…when I'm freaking out about an experiment going wrong three times…other people are like, "But that's so hard to do…" or, "You're just an undergrad and you like can't expect yourself to get real results, you know, or like ground-breaking results, you know, or make A's all the time…"

Reason	Exemplary Quote
Liking Future Career Options	…I just felt that it was a good career choice and, you know, if I finish I would be able to do something, something that would, you know, allow me to live decently. And…the flexibility, which also goes with the career choice. I felt that it was a flexible career choice. Like I could make it my own…I didn't have to go to graduate school. I didn't have to go to medical school. I could teach, or I could, you know, go into whatever I wanted…
Liking the Challenge	…it's having things come easy to you before and you realize how much better it is when you work at it and you may not get the great grades, but, I mean I wish I'd get great grades and I work real hard to get them, but even though I work real hard and don't get an A, but if I work the hardest I can do and get a B, I still feel the satisfaction of knowing that it was something that I had to try and I did it.
Never Considered Leaving	…I never had any…substantial doubts, because, you know, I had those superficial ones like, "Oh, it would be so much easier to be a blank, x, or y major" and then I'd be like, "No"…I wouldn't do it. So, you know, once I was in it, totally into it, I never had any doubts about it, that this is what I should be in.
Doing Important Work/Make a Difference	I felt that like through science, I could make a difference…this sounds cheesy, but like in the environment, in the world, in the community, what have you. Through research and through telling people, educating people, and developing new technologies, I felt that I could, you know, have a real impact on, you know, human life.
Double-majoring with a Non-Science Degree	…I really like it because…I get to take classes in like history and philosophy and literature, yet I don't have to do a career in them. So, it's like I know enough knowledge to satisfy my interests, but like it's not that I have to go into that field…I'm writing my thesis in something that's not science, so it's kind of nice, like it gives it a balance for me.
Impressing Others	And anytime I tell somebody my major. "Yeah, I'm a microbiology major." "Oh my God, really?! I can't…that's so hard!" I get a kick out of it…impressing people…I think it's hilarious 'cause it's not harder than anything else or anybody makes it.
Focus on a Career Connected to the Major	…trying to focus on…where I wanna be, like doing forensics…like I see glimpses of what I could be doing and it makes me wanna stay and keep doing it.

Reason	Exemplary Quote
Did Not Take Science Freshman Year	If I'd taken biology and chemistry and probably calculus, through my freshman year, I'd probably been overwhelmed. I'm not kidding. Since I had such an easy first year…It was just like languages and psychology and philosophy, really like easy classes. So, I mean, at the end of it, I was like "Okay, college isn't nearly as they're making it sound" and I was kind of upset. But, I was happy to be challenged my second year. But, had I taken it my first year, I'd probably be completely different.
Switching to Another Major	Personally, what made me come back to biology was actually switching to psychology because when I switched to psychology, I really enjoyed what I was doing, but I realized how limited their viewpoint was, so I thought that I really needed the science background in me.
Not Disappointing Parents	I didn't wanna let myself down, but more importantly, I don't wanna let my parents down 'cause, you know, it's easy to let myself down. It's hard to let your parents down…Switching. That means you would've failed. You couldn't take it. I didn't want my parents to know that I couldn't take it.
Pursuing a BA rather than a BS in biology	I like that I can spend four semesters with a foreign language and I like learning like neurobiology, only taking one or two classes, but I don't wanna take ten 'cause I feel like there can be a lot of repetition in biology too, and that can be discouraging, kind of take away from your motivation sometimes. So I don't want that to happen.
AP Credit for Introductory Biology	I tested out of those classes. Like, maybe that's why I'm still a bio major…
Better Prepared for Medical School	Well, I still have the mentality that, you know, if I do make it to med school, then, you know, I would [be] above like the other students who weren't bio majors or science majors.

THE PHENOMENON OF LEAVING

To get as complete a story of the phenomenon of leaving as possible, it was not only important to uncover why switchers left the major, but it was also important to find out 1) when students were most likely to leave the major; 2) who is most likely to leave the biology major in terms of demographic characteristics; and 3) where switchers went in terms of their major course of study. Therefore, this section begins with the reporting

of institution-wide data detailing these items, continues with the presentation of quantitative and qualitative data concerning participants' reasons for leaving the biology major, and concludes with descriptions of how switchers chose their new major.

When Do Switchers Leave Biology?

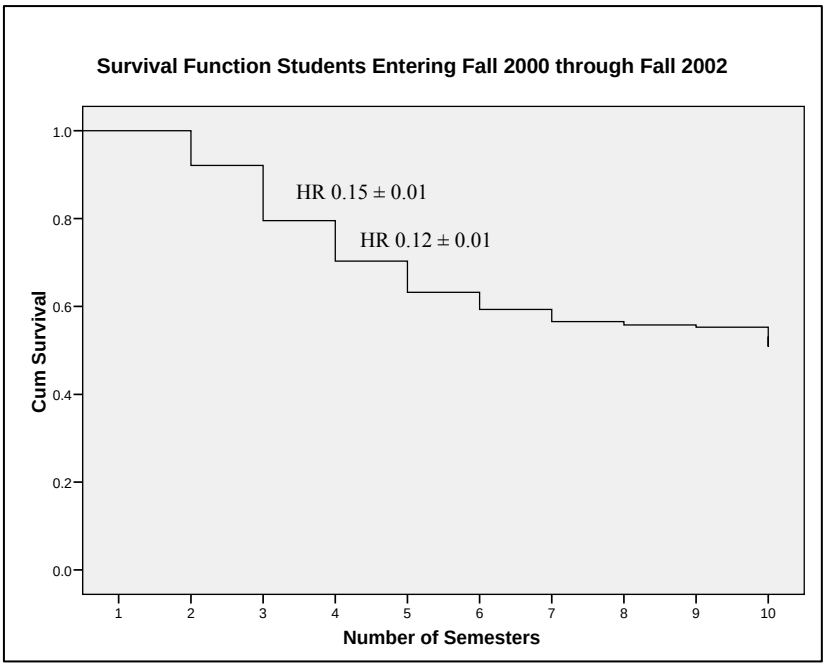
As portrayed in Table 4.50 and Figure 4.1, survival analysis of biology freshman entering The University between 2000 and 2002 and continuing through to a degree (N=1321) revealed that the majority of students who leave the biology major do so between the second and third semesters of college (HR = 0.15 ± 0.01) and between the third and fourth semester of college (HR = 0.12 ± 0.01).[43] These correspond to: 1) the time period after most students take the year-long introductory biology course their freshman year; and 2) the time period after most students take a required genetics course during their sophomore year. This is a gateway course to most upper-division courses in the major and is typically students' first upper-division experience.

Table 4.50: Life Table of Biology Freshmen, 2000-2002

Interval Start Time (Semesters)	Number Entering Interval	Number Withdrawing (Graduating)	Number Exposed to Risk	Number of Terminal Events (Switching)	Proportion Terminating (Switching)	Proportion Surviving (Staying)	Cumulative Proportion Surviving at End of Interval	Hazard Rate (HR)
0.000	1321	0	1321.0	0	0.00	1.00	1.00	0.00
1.000	1321	0	1321.0	104	0.08	0.92	0.92	0.08
2.000	1217	0	1217.0	166	0.14	0.86	0.80	0.15
3.000	1051	0	1051.0	122	0.12	0.88	0.70	0.12
4.000	929	0	929.0	93	0.10	0.90	0.63	0.11
5.000	836	0	836.0	51	0.06	0.94	0.59	0.06
6.000	785	0	785.0	35	0.04	0.96	0.57	0.05
7.000	750	0	750.0	9	0.01	0.99	0.56	0.01
8.000	741	517	482.5	4	0.01	0.99	0.56	0.01
9.000	220	125	157.5	6	0.04	0.96	0.54	0.04

[43] Observe that the numbers on the x-axis indicate the beginning of the particular semester.

Figure 4.1: Survival Curve of Biology Freshmen, 2000-2002



Based upon survival analysis, as shown in Tables 4.51 and 4.52, students who switched to non-STEM majors were approximately twice as likely to leave at each time point as students who switched to other STEM majors. For example, the hazard rate for non-STEM students between the second and third semesters was 0.10 ± 0.01 while that for STEM majors was 0.05 ± 0.01. The relative proportions leaving each semester was the same for each group, with the majority of each leaving between the second and fourth semesters. The one exception to this is survival from the sixth to seventh semesters. Figure 4.2 shows a side-by-side comparison of students who switched to non-STEM majors with those who switched to STEM majors. As shown in the above tables, the figures demonstrate the clear difference in the survival rates of these two groups of students.

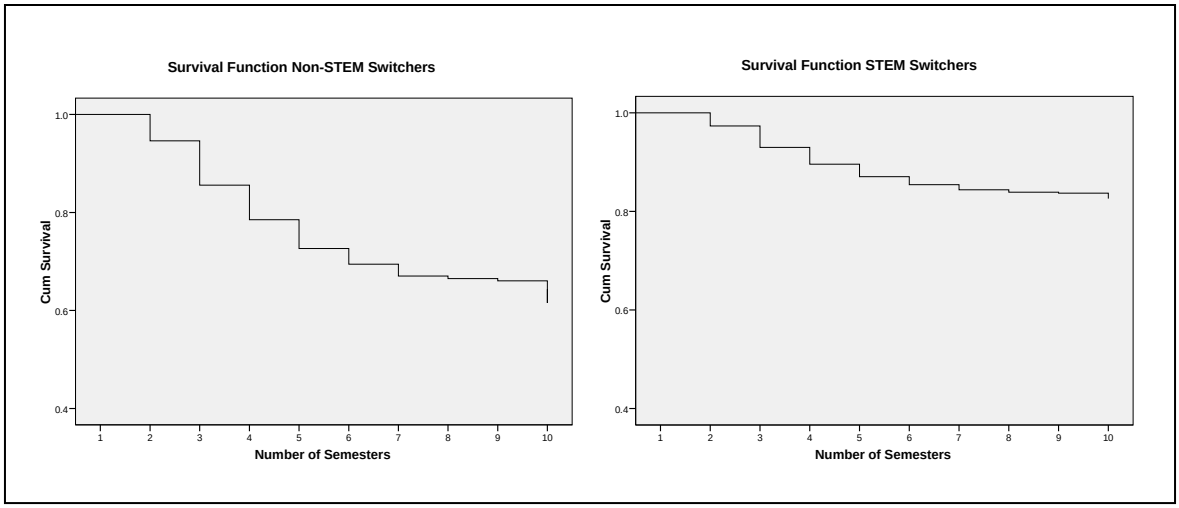
Table 4.51: Life Table of Biology Freshmen Switching to Non-STEM majors, 2000-2002

Interval Start Time (Semesters)	Number Entering Interval	Number Withdrawing (Switching to STEM or Graduating)	Number Exposed to Risk	Number of Terminal Events (Switching to non-STEM)	Proportion Terminating (Switching to STEM)	Proportion Surviving (Staying)	Cumulative Proportion Surviving at End of Interval	Hazard Rate (HR)
0.000	1321	0	1321.000	0	.00	1.00	1.00	.00
1.000	1321	34	1304.000	70	.05	.95	.95	.06
2.000	1217	53	1190.500	114	.10	.90	.86	.10
3.000	1050	37	1031.500	85	.08	.92	.79	.09
4.000	928	34	911.000	68	.07	.93	.73	.08
5.000	826	20	816.000	36	.04	.96	.69	.05
6.000	770	53	743.500	26	.03	.97	.67	.04
7.000	691	48	667.000	5	.01	.99	.67	.01
8.000	638	415	430.500	3	.01	.99	.66	.01
9.000	220	127	156.500	4	.03	.97	.64	.03

Table 4.52: Life Table of Biology Freshmen Switching to STEM majors, 2000-2002

Interval Start Time (Semesters)	Number Entering Interval	Number Withdrawing (Switching to Non-STEM or Graduating)	Number Exposed to Risk	Number of Terminal Events (Switching to STEM)	Proportion Terminating (Switching to STEM)	Proportion Surviving (Staying)	Cumulative Proportion Surviving at End of Interval	Hazard Rate (HR)
0.000	1321	0	1321.000	0	.00	1.00	1.00	.00
1.000	1321	70	1286.000	34	.03	.97	.97	.03
2.000	1217	115	1159.500	52	.04	.96	.93	.05
3.000	1050	85	1007.500	37	.04	.96	.90	.04
4.000	928	77	889.500	25	.03	.97	.87	.03
5.000	826	41	805.500	15	.02	.98	.85	.02
6.000	770	70	735.000	9	.01	.99	.84	.01
7.000	691	49	666.500	4	.01	.99	.84	.01
8.000	638	417	429.500	1	.00	1.00	.84	.00
9.000	220	129	155.500	2	.01	.99	.83	.01

Figure 4.2: Survival Curves of Biology Freshmen Switching to Non-STEM and STEM Majors, 2000-2002



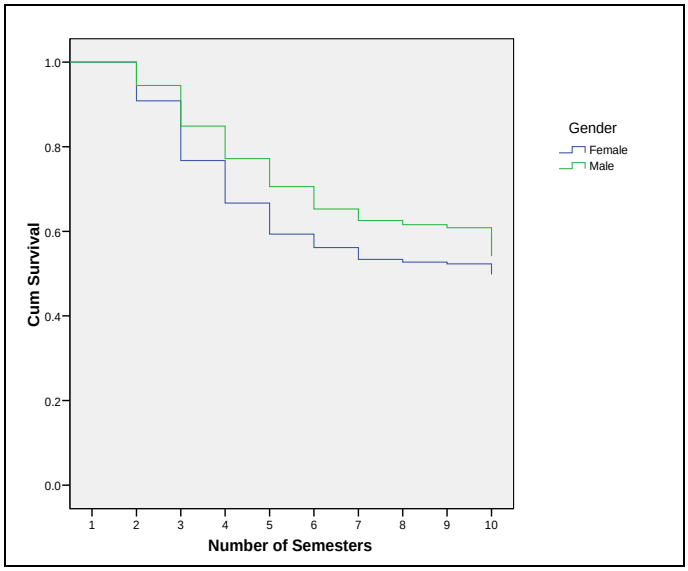
Who Is Leaving Biology?

In terms of gender and despite the greater representation of women in the biology major, Kaplan-Meier comparisons demonstrated that men (n=456) were 1.099 to 1.736 times[44] more likely than females (n=865) to persist in the major, x^2=11.255, p=0.001. The primary source of this was the differential survival of White males (n=226) over White females (n=427) in the major, x^2=8.158, p=0.004, 95% CI: 1.174 to 2.267 (Figure 4.3). Observe that the separation begins to occur during the third semester. There were no significant differences among the survival of Asian-American males (n=138) over Asian-American females (n=237), x^2=0.342, p=0.559 or Latinos (n=74) over Latinas (n=148), x^2=1.396, p=0.237. Although there was a significant difference in the survival of African-American males (n=14) over African-American females (n=39), x^2=4.277, p=0.039, 95% CI: 1.004 to 12.972, this is likely a relic of the low sample size, as indicated by both the low power and abnormally wide CI range (1-β =0.572).

[44] 95% CI for the Hazard Ratio (HR). Recall that a hazard ratio over 1 that does not have a 95% CI lower bound below 1 is considered an important result.

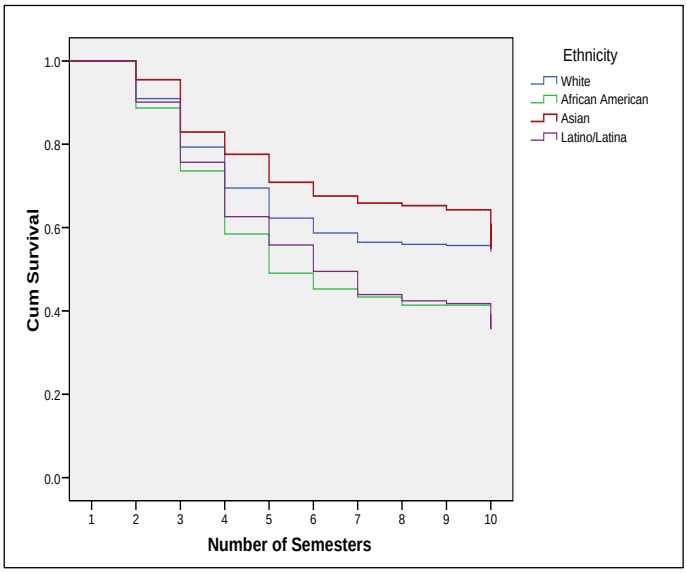
In terms of generation status, Kaplan-Meier comparisons demonstrated that first generation college students (n=153) were no more likely than traditional college students (n=1168) to leave the major, x^2=0.117, p=732. Even when gender and ethnicity were taken into account, there were no significant differences between first generation and traditional college students that could be attributed to generational status.

Figure 4.3: Survival Curves of Biology Freshmen by Gender, 2000-2002



In terms of ethnicity, Kaplan-Meier comparisons demonstrated that Asian-American students (n=375) were more likely than White students (n=653) to persist in the major and White students were more likely than African-American students (n=53) and Latino students (n=222) to persist in the major, x^2=31.870, df=3, p<0.001 (Figure 4.4). Observe that the separation between Asian-American and other students begins to occur after the first semester and the gap widens after the second and third semester, remaining rather consistent following that time period. Because of the comparatively small African-American student population and because there was no significant difference in the persistence between African-American and Latino students (x^2=0.020, p=0.887) these groups were combined in later analyses.

Figure 4.4: Survival Curves of Biology Freshmen by Ethnicity, 2000-2002



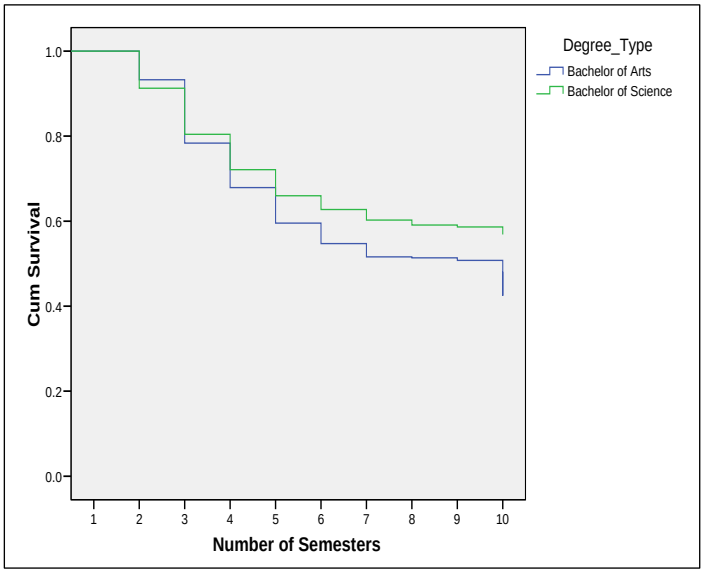
Additional analyses of the effect of gender revealed that the primary source of the difference between Asian-American and White students was due to the differential survival of Asian-American females (n=237) over White females (n=427), x^2=8.635, p=0.003, 95% CI: 1.133 to 2.160. There was no significant difference in the survival of Asian-American males (n=138) over White males (n=226), x^2=0.371, p=0.543. Additionally, White students were 1.323 to 2.344 times (95% CI) more likely than African-American and Latino students (n=275) to persist in the major, x^2=13.838, p<0.001. Additional analysis of gender effects revealed that, unlike the difference between Asian-American and White students, the difference between Whites and African-American/Latino students was significant across genders (Females: x^2=9.090, p=0.003; Males: x^2=4.456, p=0.035).

In terms of advising area, Kaplan-Meier comparisons demonstrated that students classified as health professions upon enrollment (n=420) were not significantly more likely than students who were classified as none or other (n=921) to stay in the major,

x^2=3.807, p=0.051, 95% CI: 0.931 to 1.482. Later analysis revealed that this almost significant result is due largely to the aforementioned association between being in a health professions area and seeking a BA degree (Table 4.15, and discussed below).

In terms of degree sought, Kaplan-Meier comparisons demonstrated that students Bachelor of Arts degree seekers (n=564) were 1.556 to 1.938 times more likely than Bachelor of Science degree seekers (n=757) to leave the major, x^2=7.646, p=0.006 (Figure 4.5). Observe that this separation begins to occur during the fourth semester. Further analysis revealed that this was modulated by two other factors in combination: gender and advising area, respectively. There was no association between degree or health professions status and ethnicity. First, there was a greater survival of female BS degree seekers (n=484) over female BA degree seekers (n=381), x^2=112.634, p<0.001, 95% CI: 1.187 to 2.038. There was no significant difference in survival rates of male BA degree seekers (n=183) and male BS degree seekers (n=273), x^2=0.221, p=0.638, 95% CI: 0.911 to 1.941. Furthermore, female BA seekers were 1.008 to 2.044 times as likely to leave as male BA degree seekers (x^2=16.612, p<0.001), but there was no significant difference in survival rates of male and female BS degree seekers (x^2=0.697, p=0.404). This implies that the choice of the BA degree is a factor in departure of female students and not male students. Secondly, there was a greater survival of BS health professions students over BA health professions students (x^2=6.737, p=0.009, 95% CI 1.353 to 2.953). There was no significant difference in the survival rates of BS non-health professions students, BA non-health professions students and BA health professions students (x^2=2.966, p=0.227) indicating that orientation toward both academic (a specific biology concentration) and professional (in this case, health professions) goals is associated with persistence.

Figure 4.5: Survival Curves of Biology Freshmen by Degree Sought, 2000-2002



To uncover which factors had the greatest contribution to switching, I analyzed all of the above factors using Cox regression with the forward stepwise method. White students are not shown in the analysis because the white ethnicity was loaded as the reference point for the other ethnicities. As shown in Table 4.53, the final model included ethnicity, gender and degree type, with the former two contributing the most to the regression model. Based upon the Exp(B), or the instantaneous relative risk, those at highest risk of leaving the biology major are African Americans, Latinos/Latinas, and female students. Because Exp(B) values for Asian Americans and Bachelor's of Science degree seekers are below 1, they both lessen the risk. In simpler terms, this means that, for female students being an Asian American female or one seeking a BS degree will lower the hazard risk. Similarly, for African American and Latino students, seeking a BS degree will lower the hazard risk.

Table 4.53: Cox Regression of Demographic Variables (continued on next page)

Case Processing Summary		N	Percent
Cases available in analysis	Event (Dependent Variable: Number of Semesters in Biology Major)	585	35.4%
	Censored	718	43.4%
	Total	1303	78.8%
Cases dropped	Cases with missing values	351	21.2%
	Cases with negative time	0	.0%
	Censored cases before the earliest event in a stratum	0	.0%
	Total	351	21.2%
Total		1654	100.0%

Block 0: Beginning Block
Variables not in the Equation(a)

	Score	df	Sig.
Ethnicity	28.688	3	.000
Ethnicity(African American)	3.610	1	.057
Ethnicity(Asian American)	15.557	1	.000
Ethnicity(Latino/Latina)	17.157	1	.000
Gender (Female)	10.726	1	.001
Generation (First Generation)	.053	1	.818
Degree Type (Bachelor of Science)	6.311	1	.012
Original Area (Health Professions	3.825	1	.051

a Residual Chi Square = 48.652 with 7 df Sig. = .000

Block 1: Method = Forward Stepwise (Likelihood Ratio)
Omnibus Tests of Model Coefficients(d,e)

Step	-2 Log Likelihood	Overall (score)			Change From Previous Step			Change From Previous Block		
		Chi-square	df	Sig.	Chi-square	df	Sig.	Chi-square	df	Sig.
1(a)	8074.233	28.688	3	.000	27.752	3	.000	27.752	3	.000
2(b)	8063.977	38.632	4	.000	10.257	1	.001	38.009	4	.000
3(c)	8057.564	44.968	5	.000	6.412	1	.011	44.421	5	.000

a Variable(s) Entered at Step Number 1: Ethnicity
b Variable(s) Entered at Step Number 2: Gender
c Variable(s) Entered at Step Number 3: Degree_Type
d Beginning Block Number 0, initial Log Likelihood function: -2 Log likelihood: 8101.985
e Beginning Block Number 1. Method = Forward Stepwise (Likelihood Ratio)

Table 4.53: Cox Regression of Demographic Variables (continued from previous page)

Variables in the Equation

		B	SE	Wald	df	Sig.	Exp(B)	95.0% CI for Exp(B)	
								Lower	Upper
Step 1	Ethnicity			28.126	3	0.000			
Ethnicity (African American)		0.340	0.190	3.188	1	0.074	1.404	0.967	2.039
Ethnicity (Asian American)		-0.277	0.105	7.042	1	0.008	0.758	0.617	0.930
Ethnicity(Latino/Latina)		0.336	0.105	10.180	1	0.001	1.400	1.138	1.721
Step 2	Ethnicity			27.346	3	0.000			
Ethnicity (African American)		0.330	0.190	3.002	1	0.083	1.390	0.958	2.019
Ethnicity (Asian American)		-0.272	0.105	6.783	1	0.009	0.762	0.620	0.935
Ethnicity (Latino/Latina)		0.334	0.105	10.059	1	0.002	1.397	1.136	1.717
Gender (Female)		0.284	0.090	9.909	1	0.002	1.328	1.113	1.585
Step 3	Ethnicity			27.608	3	0.000			
Ethnicity(African American)		0.350	0.190	3.391	1	0.066	1.420	0.978	2.061
Ethnicity(Asian American)		-0.278	0.105	7.068	1	0.008	0.757	0.617	0.930
Ethnicity(Latino/Latina)		0.326	0.105	9.593	1	0.002	1.386	1.127	1.704
Gender (Female)		0.283	0.090	9.876	1	0.002	1.327	1.112	1.584
Degree Type (B.S.)		-0.211	0.083	6.444	1	0.011	0.810	0.689	0.953

Model if Term Removed

Term Removed		Loss Chi-square	df	Sig.
Step 1	Ethnicity	27.752	3	.000
Step 2	Ethnicity	26.973	3	.000
	Gender	10.257	1	.001
Step 3	Ethnicity	27.279	3	.000
	Gender	10.221	1	.001
	Degree Type	6.412	1	.011

Each of the results presented in the above section are summarized in Table 4.54. Groups positioned in the same columns have the same relative survival rates. In the simplest terms, the demographic factors in the far left column lower hazard risk by the greatest amount and those in the middle column lower hazard risk by a smaller amount.

Table 4.54: Summary Survival Rates of Demographic Groups

Highest Survival Rate	Medium Survival Rate	Lowest Survival Rate
White Men Asian Men Asian Women	White Women	African American Men African American Women Latino Men Latino Women
Female BS Degree Seekers Male BS Degree Seekers Male BA Degree Seekers	Female BA Degree Seekers	
BS Health Professions	BA Health Professions BA Non-Health Professions BS Non-Health Professions	

Where Do Switchers Go?

As portrayed in Table 4.55, analysis of the biology freshman entering The University between 2000 and 2002 and continuing through to a degree (N=1321) revealed that 70.1% of switchers leave biology for non-STEM disciplines and 29.9% leave for other STEM disciplines (marked with an asterisk).

Table 4.55: Final Major of Biology Freshmen, 2000-2002

Major	Frequency	Percent	Valid Percent
Biology	729	44.1	55.2
Business	21	1.3	1.6
Education	75	4.5	5.7
Engineering*	18	1.1	1.4
Fine Arts	5	0.3	0.4
Social Work	6	0.4	0.5
Pharmacy*	10	0.6	0.8
Architecture	3	0.2	0.2
Communication	63	3.8	4.8
Liberal Arts	242	14.6	18.3
Other Natural Science*	125	7.6	9.5
Nursing*	24	1.5	1.8
Total	1321	79.9	100.0
Missing (Left without degree/Unknown)	333	20.1	
Total	1654	100.0	

* STEM disciplines

Because biology majors are required to take chemistry and physics as part of the major and the majority of switchers leave for non-STEM disciplines, this implies that a

considerable portion of switchers are turned off to the other sciences during their time as a biology major. This is supported by the data presented in Table 4.56, showing that very few of these switchers "switch up" into chemistry, computer science, mathematics, or physics.

Table 4.56: Final Natural Science Major of Biology Switchers, 2000-2002

Natural Science Major	Frequency	Percent of Natural Science Switchers	Percent of All Switchers (n=592)
Biochemistry	20	16.0	3.3
Chemistry	3	2.4	0.5
Computer Science	4	3.2	0.7
Geology	4	3.2	0.7
Human Development and Family Science	51	40.8	8.6
Mathematics	8	6.4	1.4
Nutrition	25	20.0	4.2
Physics	1	0.8	0.2
Textiles and Apparel	9	7.2	1.5
Total	125	100.0	21.1

Reasons for Leaving: Quantitative Results

Table 4.57 presents the reasons most reported by switchers for leaving the biology major, five of which involve comparison of biology to some other discipline, including two that mention performance. Also prominent in these results are the lack of suitability of biology (biology was wrong for me, my talents are best suited).

Table 4.57: Top Reasons Switchers' (N=107) Reported Leaving the Biology Major (proportion > 0.50; in descending score order)

Reason (3 Moderately True of Me to Completely True of Me 5)	M	Score	Prop.
I preferred another discipline over biology	4	3.33	0.79
I changed my mind about what I wanted to do after college	4	2.94	0.67
I was more interested in other courses than my biology courses	3	2.82	0.69
My talents are best suited to another discipline besides biology	3	2.77	0.67
I found out I have a higher aptitude for another discipline	3	2.70	0.67
I performed better in other courses than I did in biology courses	3	2.41	0.57
I felt that biology was wrong for me	3	2.21	0.55

Mann-Whitney comparison of STEM and non-STEM switchers' reasons for choosing biology (Table 4.58) demonstrates that STEM switchers were more likely to report leaving the major due to job opportunities, while non-STEM switchers were more likely to report difficulties with their instructors, classmates, and the pace of their courses. These latter reasons demonstrate that non-STEM switchers were turned off to biology. In addition, non-STEM switchers were more likely to report being more interested in their other courses.

Table 4.58: Comparison of STEM (S) Switchers (N=51) and Non-STEM (NS) Switchers' (N=56) Reasons for Leaving Biology ($p<0.05$; in descending effect size order).

Reasons for Leaving the Biology Major (1 Not at all True of Me to Completely True of Me 5)	M (S)	M (NS)	M-W U	Z	Sig. (2-tailed)	Effect size (r)
I would have better job opportunities with a degree in another discipline	3	1	1000	-2.842	0.004[§]	0.275
The lack of support I received from my biology instructors	1	2	1062.5	-2.534	0.011[§]	0.245
I did not like the way I was treated by my biology instructors (S<NS)	1	1	1134	-2.203	0.028[§]	0.213
The lack of support I received from my fellow biology students (S<NS)	1	1	1165	-2.076	0.038[§]	0.201
I had difficulty handling the pace of my biology courses	1	2	1119	-2.024	0.043[§]	0.196
I was more interested in other courses than my biology courses	3	4	1118.5	-1.983	0.047[§]	0.192

[§]Exceeds Bonferroni-corrected p-value 0.0013

Table 4.59 presents the non-significant Mann-Whitney comparisons of STEM and non-STEM switchers in terms of their reasons for leaving the biology major. Based upon these data the groups are very similar with respect to the majority of the reasons they left the major, with the top five reasons mirroring five of the six top reasons listed in Table 4.57.

Table 4.59: Comparison of STEM (S) Switchers (N=51) and Non-STEM (NS) Switchers' (N=56) Reasons for Leaving Biology (NS; in decreasing median order; continued on next page).

Reasons for Leaving the Biology Major (1 Not at all True of Me to Completely True of Me 5)	M (S)	M (NS)	M-W U	Z	Sig. (2-tailed)	Effect size (r)
I preferred another discipline over biology	4	4	1187	-1.559	0.120	0.151
I changed my mind about what I wanted to do after college	3	4	1212.5	-1.395	0.163	0.135
I found out I have a higher aptitude for another discipline	3	4	1249	-1.143	0.256	0.110
My talents are best suited to another discipline besides biology	3	4	1264.5	-1.044	0.299	0.101
I performed better in other courses than I did in biology courses	3	3.5	1169.5	-1.659	0.098	0.160
I felt that I did not belong or fit in the biology major	2	3	1219	-1.340	0.182	0.130
I lost interest in a career or profession for which biology was helpful or required	2	3	1262.5	-1.081	0.281	0.105
I felt that biology was wrong for me	1	3	1220.5	-1.329	0.185	0.128
Biology was difficult for me	2	2	1163	-1.727	0.084	0.167
I had difficulty handling the amount of work required in my biology courses	2	2	1169.5	-1.683	0.093	0.163
I performed poorly in biology	2	2	1293.5	-0.883	0.380	0.085
I found out that I did not need to major in biology to prepare for or enter my chosen career	2	2	1422	-0.039	0.988	0.004
I have gotten a better education my other courses than I did in my biology courses	2	1.5	1334	-0.629	0.531	0.061
I would make a better living with a degree in another discipline than with a degree in biology	2	1	1272	-1.045	0.299	0.101
I lost interest in biology	2	1	1270	-1.038	0.301	0.100
I had difficulty handling the amount of information I was expected to learn	1	2	1161.5	-1.741	0.082	0.168
I did not like my biology courses	1	2	1179	-1.614	0.110	0.156
I felt that I could not succeed in biology	1	2	1206	-1.457	0.145	0.141
A biology degree will not prepare me for what I want to do after college	1	2	1224.5	-1.332	0.184	0.129
I have learned more in my other courses than in my biology courses	1	2	1227	-1.316	0.189	0.127
I did not like the way my biology courses were taught	1	2	1241	-1.245	0.215	0.120

Reasons for Leaving the Biology Major (1 Not at all True of Me to Completely True of Me 5)	M (S)	M (NS)	M-W U	Z	Sig. (2-tailed)	Effect size (r)
I grew to dislike biology	1	2	1304.5	-0.833	0.412	0.081
I did not like the learning experiences that my biology courses provided for me	1	2	1408.5	-0.131	0.899	0.013
It would have taken too long to finish a biology degree	1	1	1292	-1.099	0.280	0.106
It would have taken too much money to finish a biology degree	1	1	1322.5	-0.989	0.352	0.096
Someone discouraged me from staying in the major	1	1	1306.5	-0.959	0.342	0.093
It would have taken too much effort to finish a biology degree	1	1	1294	-0.936	0.353	0.090
The lack of support I received from my biology advisor	1	1	1303	-0.900	0.379	0.087
Someone encouraged me to change my major	1	1	1357	-0.513	0.616	0.050
My other instructors were better or more effective teachers than the ones from biology	1	1	1380.5	-0.335	0.740	0.032
The career opportunities in biology were not worth the time, money, or effort it would take	1	1	1379.5	-0.329	0.747	0.032
I did not like the competitive nature of my biology courses	1	1	1396	-0.219	0.829	0.021

Reasons for Leaving: Qualitative Results

As shown in Table 4.60, with the exception of fit and performance in the biology major, the qualitative results did not echo the quantitative results. Where most of the questionnaire participants reported leaving the biology major due to preference for another discipline, none of the interview participants did. In fact, most switchers decided to leave biology prior to finding a new major, spending one to three semesters investigating other majors before declaring a new one. Whether this incongruence is due to a sampling effect or the *ex post facto* nature of the study (i.e. switchers prefer their new discipline now and therefore must have at the time they switched), is up for speculation. Each of the major reasons reported by persisters (frequency effect size of 0.333 and greater) are described in the next section. Exemplary quotes demonstrating less salient reasons can be found in Table 4.61.

Table 4.60: Reasons Switcher Participants Reported Leaving the Biology Major, N=16 (In descending order of frequency effect size)

Switcher Reasons for Leaving Biology	Switcher Frequency Effect Size
Difficulties with Workload	0.750
Not Interested in Jobs Connected to Biology	0.563
Not Belonging/Fitting In	0.500
Not Interested in Biology	0.500
Personal Encouragement to Switch Majors	0.500
Poor Performance in Courses Required for Major	0.438
No Longer Going to Medical School	0.375
Exposure to Another Discipline while in College[45]	0.313
Not Learning Enough	0.313
Other Interest Besides Biology	0.250
Financial Concerns	0.188
Lack of Mentors	0.188
Not Liking Biology	0.188
Personal Discouragement from Staying in Biology	0.063

Difficulties with Coursework or Workload

The most common reason switchers left the major was due to difficulties with the workload required of their courses, including biology and non-biology requirements such as chemistry: "I think I started to believe I was in the wrong major 'cause everything I felt like was too hard for this to be…what I'm supposed to be doing for the rest of my life." For some of these switchers, it was not just the amount of work required, but that being in the biology major was not worth the work: "[I asked myself], 'How hard am I really going to try at this? How hard can I force myself to try at this when I know how much work it takes for me to do well in it, even if I can?'" For most of the switchers, the recognition of the work involved in the biology major came during their freshman year. All but two of the switchers who noted difficulties as a reason for switching described those they faced their first year of college: "Freshman year I did not have a life. I never

[45] Note that participants who reported leaving, in part, due to exposure to another discipline did not switch to the discipline connected to that course (i.e. preference for another discipline)

left my dorm room. I was always studying. And…that's kind of why I changed majors 'cause that was the most depressing year of my life."

Interestingly, persisters did not disagree with the assessment that the biology major required a lot of work. Almost half (9 out of 19) of the persisters interviewed described non-science majors as having it easier than science majors, specifically due to the workload of science courses. Most of these persisters reported workload incongruence as something that has made it harder to be in the biology major or a reason they did not "hang out" with people in other majors. In many cases, these participants reported a sense of jealousy or injustice because they felt they had to do more work than other students to get their degree, as two persisters discussed during a focus group (second participant in bold):

> I don't think non-science majors, in general, spend as much time doing anything.
>
> **I know. Like, "Oh, maybe I should switch to a different school altogether."**
>
> Yeah **=Like comparing to like my roommates and stuff, who were doing business, or, you know, RTF,[46] or whatever, it was like they had more fun and** =Yeah **=not necessarily more fun, but [more] time** =less stress. Yeah, less stress and less, like they didn't have to go up to school to check their micro lab **=Right, or plan accordingly for the [weekend] to make sure their experiments are timed correctly.**
>
> [Exactly]
>
> **And it's just another thing to worry about…Yeah, my roommate second year was an education major, so she just** =Oh, gosh **=I mean, she spent her time reading <u>Charlotte's Web</u>. I'm like, "Are you kidding?"** =I know my roommate now is and I'm so jealous. All she does is go to school and teach **=Yeah, all she does is teach little kids all day. You are so lucky and you're going to get a degree from [here], which is probably worth as much as my degree…, which is depressing.**

In addition, several of these participants (switchers and persisters) spoke of what they had to give up, usually in terms of their social life: "Studying all the time and that was really

[46] Radio-Television-Film

difficult for me because I was used to being able to go out and have fun with my friends and it was also frustrating because my roommate at the time was a psych major and she was out having fun all the time."

Not Interested in Jobs Connected to the Biology Major

Another significant reason switchers reportedly left the major was that they were not interested in the jobs connected to the major. These responses often referenced the switchers' back-up plan in case they did not get into or changed their mind about medical school:

> You know, I was thinking, "If I don't make it to medical school, what will I really do with a biology degree?" And there was nothing. I didn't wanna do research. I didn't wanna teach anybody. And so, there was nothing I could have done with the biology degree. And so, I was like, "I'm gonna…drop it and find something I could do in case med school doesn't happen for me."

In addition, a few of these switchers described the process they went through to come up with the realization that they were not interested in biology job options:

> Yeah, I think I really didn't have a clue coming into biology, you know, just from what my dad said, I kind of was feeling like, "Well, biology will give me lots of possibilities and a lot of security," and…I just kind of was working the first three years on this basis of knowledge that I really didn't understand any further than I just said then. So when I came to like, "Well, what are these…different possible routes that I can take? And what are these great things that I can do with this biology that I'm interested in?" And…I went through each one. I was like, "Oh yeah, maybe I could do this," and as I'd research it further, not that wasn't for me, and just knocked them down one by one…until they were all gone and I was just like, "No, none of these work."

A few others, including the above switcher, mentioned the uncertainty and lack of security that biology students reported to them:

> …there's a lot of uncertainty about, if you graduate with a biology degree, what you're gonna do after that if you don't go to medical school. I mean, actually, I think everyone that I know who's a biology major definitely worries about that, 'cause…unless you're gonna wanna become like a teacher in biology, there's not really a whole lot of options directly for graduates to go to. I mean, in my lab, like there's a couple graduating and they're like ecology majors and they're like,

> "I don't know what I'm gonna do." They didn't wanna go to med school. They just got a straight biology degree, so they're trying to find things to do, as in fieldwork, and if you don't like fieldwork and you're going into biology, then what are you gonna do? You gotta teach, or at least that's…what we're told."

None of these switchers could list jobs connected to the biology major besides research and teaching, the former of which they often lamented requires additional schooling, as the above switcher reported: "…it just feels like, if you graduate with a biology degree, you're not really gonna do much unless you go do some higher education." As with the workload misgivings, few of the persisters seemed to disagree, either noting that they had plans to go to graduate school anyway, or complaining about how little money they could make with only a Bachelor's in biology, as one persister explained to another focus group participant, "At _____, if I become a lab tech with my BS in bio, I can make between 22 and $30,000 a year…All this work for nothing. All of them, you can only make over 30 if you have your Master's, [so] basically a Bachelor's degree in biology is worth crap…I thought having a science degree'd be worth a lot more money."

Not Belonging/Fitting In

Another reason switchers reported leaving the biology major is because they felt as if they did not belong with or did not fit into the major, primarily due to the behavior or perceptions of other biology students. In general, there were three types of "not belonging" responses: 1) not belonging because others had a better grasp of course material, 2) not belonging because others were more serious about their future plans, and 3) not belonging because they did not feel others were an intellectual or social match. The most common "not belonging" response had to do with switchers' perception of other students' ability to understand material:

> I felt like the other kids on the class…with the exception of a couple of my friends [both of whom ultimately left: author note]…were just getting it so fast and I was like, "Why am I not getting this. I've always been like a smart kid and…now…I

> feel like I'm like the dunce of the class and that I have to ask the same question again and again 'cause I don't get it and everyone else gets it." And so I though, you know, "Maybe it's…not that I'm stupid, it's just that I'm not right for biology.

The next kind of "not belonging" response was that a couple of the switchers perceived other students were, by comparison, more serious about either their coursework or their post-graduation pursuits:

> Well, I did notice that I was indifferent to things and I noticed that because I noticed other students who were actually taking it very seriously and who were actually doing very well…I hadn't actually encountered students who were ultra-enthusiastic about school or anything like that, not in high school or before that. But in college, there were actually students who were…biologists in biology class.

The last kind of "not belonging" response was that a few of the switchers were turned off by the behavior or appearance of other science students, as two switchers discussed in a focus group (second switcher in bold):

> Yeah, the people in my physics lab are so weird too.
>
> **Yeah, you have to be partners with these people [and I'm like, "You're weird.]**
>
> [They're really weird looking.]
>
> **Yeah!**
>
> …I walked into the room the first day, and this is what turned me away from medicine. I was looking around and it's like---'cause this class is calculus-based, just to prepare for the MCAT, blah, blah---it's like, "These people, they don't act anything like me. They look really weird. They act really weird. Like if this is the kind of crowd that goes to medical school, no thanks. **=Count me out.**

Both of the above switchers, who left the biology major after their sophomore year, were part of the Greek and athletics communities respectively and noted that they felt isolated because of their choice of major, as one explained: "I also found that like saying I was

biology kind of like isolated me a little bit socially…I'm in a sorority…I'd tell people I was biology and they'd be like, 'Oh…I don't really know anything about that.'" Since they did not describe social pressure as a reason they switched out of the biology major, it is unclear how that affected their decision.

Not Interested in Biology

Lack of interest was also a prominent reason switchers left the major. For the most part, leaving due to lack of interest centered on poor course experiences and sometimes one particularly bad course experience, as one switcher explained about her introductory biology course: "I got really bored…It wasn't boredom, but I wasn't…interested like I thought I would be. I was really excited…at first. It's like, 'Oh, genetics class, this will be exciting. I'll get to learn about…' and…I just got in and I was like, 'I don't wanna be here…'" For some switchers, it was not only their courses, but the discipline in general: "I just lost interest in biology. Like the whole experience, the classes, everything. Nothing was interesting at all… 'Why am I learning about plants? Why am I learning about this? Why am I learning about that? I'm not going to use it in the future.' And I was like, 'I don't wanna do this.'"

Personal Encouragement to Switch Majors

Half of the switchers reported that someone, whether a friend, a family member, or an advisor, encouraged them to change majors, as one succinctly described of his friends: "It just seemed to me and people were telling me this: 'If you don't like it, then why are you doing it?' For some of these switchers, they received this encouragement from others due to their performance in their courses: "…when I met my now fiancé, I was still a bio major and he saw how freaked out I was getting over my grades and so he

was really encouraging of me changing my major." Two of the switchers reported being encouraged to switch by their advisor:

> I'd be coming in…two, three times a semester, like, "I don't know what I'm doing with this. This is too much work. I don't really like this. This is frustrating…I'm gonna take this and I'm not gonna take anything else that's gonna monopolize my time, or compete for time, 'cause I'm gonna need a lot of time to read and practice for this." But, constantly being exhausted and frustrated and generally run down just 'cause I wasn't enjoying it. I was hating every second of it, forcing myself through it. My advisor kept picking up on things like that and gradually was like, "You know, you've been trying this for a year and a half now and, you know, I'm not trying to tell you to quit or anything, but you know, generally maybe you should pay attention to that sort of thing. Maybe there's a reason, you know. Maybe it's not meant to be, you know, and you're kind of ignoring the signs," and that sort of thing. I got the same thing from the bio advisor…was like, "What the hell were you doing?"

The commonality among each of these types of responses is that personal encouragement resulted in the switcher feeling validated. Observe that these are not like the "discouraged from staying" responses because the participants described feeling supported by the person who encouraged them to leave or rethink their major choice.

Poor Performance

Almost half of the switcher reported leaving biology due to perceived poor performance in courses required of the major: "Yeah…my grades were not great and…I realized that [biology] wasn't what I was best at. It wasn't what I was made for, so I switched out." For most of these participants, it was not poor performance in a single course, but continued poor performance in courses that was often reflected in their GPA:

> The other thing is, you know, with all the hard work I put in all [of my other] classes and stuff, I had a high GPA and I'm sitting there looking at physics and chemistry courses which are realistically threatening to bust that GPA wide open and I wasn't willing to risk that. I mean, it's like, "Great, I finished all the premed requirements and I have a bio degree, and I'm coming out of here with a 3.1 GPA when I had a 3.8." You know, "What would be the good of that to me?" So, that was a big factor.

In addition, a couple of the switchers described the devastating effect of their grades, particularly after their first semester of college: "I was on scholastic probation…and I went home…with my tail between my legs…I mean, that first round of tests and all that good stuff just made me wanna go home and cry, you know? I couldn't believe that,…here I am this…kid [who] everybody's routing for and…I'm gonna come home a failure, you know?"

Not Going to Medical School

The last salient reason switchers reported leaving the biology major was because they had decided not to continue on the medical school track. There were two types of these responses, not going to medical school because they: 1) did not earn competitive grades and 2) they did not want to spend the time or effort it would take to become a physician. Concerning the former type of response, one switcher described her "average" grades and MCAT scores as her main reason for rethinking her major:

> Well, like my grades…I'm fine, like I'm just like average though, so I'm 3.4 and my MCAT, the average was like 24 and I was like a 26, so I was right there, at just the average, you know, straight through. And I'm very involved in like school and stuff, so I was, like in campus and organizations, so I was like,
> "Well, that may help me, but it may not, and do I really want, you know, what am I going to do as a biology major if I don't get into medical school? You know, I could teach, but I don't necessarily want to be a teacher." And so I was just like, "Well, okay I'm kind of at a dead end." And then my friend got a 28 on her MCAT and has like a 3.78 and didn't get accepted into medical school, and I was like, "Well, there you go."

Concerning the latter type of response, another explained his reluctance at continuing on the medical school track:

> It was a gradual process and it was finally me just deciding that, you know, that I could be something besides a doctor, you know?...I wouldn't want to be a doctor, just because I know…the workload you have to put in and I know that I'm not suited for it. But when it started out, it was, you know, it was, "Do I want to put in this time to being a doctor?" you know?

Interestingly, of the eleven switchers initially classified as premed, only three were still premed at the time of the interview. As for the other eight, while two left the premed area prior to leaving biology, the other six left biology and the premed area at the same time. This demonstrates the perceived tie between the biology major and medical school.

Table 4.61: Exemplary Quotes of Other Reasons Switchers Reported Leaving the Biology Major

Reason	Exemplary Quotes
Exposure to Another Discipline while in College	And I took a psychology class second semester freshman year…I was like, "This is what I want. I wanna know…why."
Not Learning Enough	...I didn't like that there was no writing or speaking in the classes, so I…didn't feel safe with a [biology] degree…I mean, I would have all this knowledge and I may get into doing some research, but then how am I gonna explain that research to other people and write about it?
Other Interest Besides Biology	There were other classes that, while I'm sitting there trying to read a chapter of bio or chemistry or physics or whatever was related to the bio major, that I realized I'd rather be reading about ancient Egypt, or God help me, some kind of philosophy, or history, or government more likely.
Financial Concerns	…and I realized I was gonna have to do a lot more schooling if I wanted to have any kind of job that I was gonna be able to support myself. I didn't wanna be in school forever 'cause I can't really afford it.
Lack of Mentors	My neighbor, he was a retired physician, but he writes books…but he's just really interesting and his son is a geneticist and studies frogs and roly-polies and I went to his lab when I was a senior in high school and he was so nice, so interesting and a great personality. And then my high school biology teacher, she had a great personality as well and she was teaching…all these really cool things in biology and then I got to the biology classes and it's like, "What happened to all those really interesting personalities?...I lost it all.
Not Liking Biology	It was really unenjoyable [sic]. I'd sit in class and daydream and I wouldn't pay attention because it was just really dry.
Discouraged from Staying in Biology	…I went [to the advising office] one day and I was like, you know, "I wanna know my progress, what steps I need to take for med school." And she's like, "Well, you're not doing so well. You're not where you need to be. This and that. You need to step up." I was like, "Okay, you're putting me down," which I didn't say, but when I left…I was completely against it. I just left there feeling like, "Maybe I'm not cut out for this...Maybe this is not what I need to be doing. Maybe I'm not smart enough," or something like that.

Second Thoughts about Major Choice

To help elucidate the decision process participants underwent when leaving and to pinpoint when they first thought of leaving, I asked both switchers and persisters to describe the first time they had second thoughts about their choice of the biology major. As detailed in Table 4.60, the participants had a variety of "second thought" accounts.

Table 4.62: Life Story Participants' Second Thoughts about Choosing the Biology Major

Second Thoughts	Persisters (n=7)	Switchers (n=9)	Exemplary Quote
No second thoughts	2	0	I knew I wanted to be a biology major. I just wasn't sure how it was going to tie in with my all my other things. But I've never thought about losing biology and running away.
Grade point average	1	1	It's just like, what discouraged me, what made me think about…maybe switching is like the competition again. Everybody is like, you know, doing well and I wasn't doing well, so it made me second-guess myself.
Difficulties during first semester	2	4	Probably when I was getting my first C…Maybe this is not for me. And I was working as hard as I was. It wasn't like I wasn't studying, and I'm sure I wasn't studying right …regardless, I was still getting a C and I was not happy about it at all…
Other students leaving the major	0	1	I started to worry about it like towards the end of my freshman year when like when everyone in [the program] was dropping out of the major. I thought, "Well, you know, is this right for me too?"
Taking a non-biology course	0	1	When I was taking that chemistry course,…I realized that originally what I liked from my high school biology was actually the chemistry part…As I went on in chemistry, I figured more what I really wanted to do.
Fear of burnout before medical school	2	1	I wanted to make sure I was taking things besides math and science because I thought I would get burned out. And that's kind of the whole reason…why I doubted that I wanted to be a bio major… 'Cause I think, when I was having the doubts, I was like, "Oh, my junior and senior year, I'm only gonna take science. That's all I'm gonna be allowed to take, 'cause I have to take so many upper divisions."
Always had second thoughts	0	1	I had been thinking about [switching] the first semester I went into college, but I'd never actually acted on it 'cause I…was scared. I was scared to do it.

Almost half of switchers and a quarter of persisters recounted difficulties they had with the workload expected of them their first semester of college. All but two of these descriptions (a high performing persister and a high performing switcher), contained references to grades, but in an immediate sense, as indicated in the exemplary quote (difficulties during first semester). These differed from descriptions of comparative performance, particularly GPA, where participants made direct references to not meeting some perceived standard as determine by other students. In both cases, these students had second thoughts well into their sophomore year of college. Lastly, observe that only one participant reported their attraction to another discipline as a source for their second thoughts, while the rest did so due to negative perceptions of the biology major.

Finding a New Major

The events leading up to as well as stated reasons for departure only comprise one part of switchers' stories of leaving. The other part of the leaving process includes researching and finding a new major, an act that often occurred during or after switchers left. For each of the switchers interviewed, the period encompassing their second thoughts about biology (above) and the time they actually found a new major took from one to six semesters. Several of the switchers spent this length of time giving science a second or third chance, as well as either investigating or "trying on" other majors, as one switcher described the process she underwent before changing her major to psychology:

> I actually jumped around several times, trying to figure out what I wanted to major in. I think I went right away to nutrition, cause the next semester I didn't really…know what I wanted to major in, so I took just a bunch of random classes and I happened to take Nutrition and I enjoyed it and so I was like, "Well, I'll major in nutrition" and then after looking…at what I was gonna need to take to graduate, I saw I was gonna need chemistry. I was like, "Okay, no. Next!" you know? And…there was several majors that I considered…that I would have liked to have majored in, but I didn't because you would have to like apply to get in. Like, you know, I was kinda getting a little bit desperate, like, "What can I do?" I

> was like, "I can be an art teacher," you know, or something like that, and I was like, "Well, you have to get accepted into art school." I know nothing about art.

Similarly, another switcher explained that, after giving biology another chance, he changed majors three times, from biology to undeclared natural sciences, to undeclared liberal arts before choosing the government program:

> I went Undeclared Natural Sciences because…I didn't wanna be a biology major anymore. I thought maybe I'd wanna do something in science…and so, I went Undeclared, kind of fiddled around with a couple more science classes and then, it was that one, first semester sophomore year. I went into it and…it was just the same, same stuff…I was Undeclared Natural Sciences, it was weird, I tried to get into Public Relations but…in order to get into Public Relations, you had to be enrolled in [advertising], which is another hell course…There were so many Advertising/PR majors, that you had to make a B in this class to move on…I got two C's in [the course] and found out that I would have to do something else…this semester I got the gumption up to go to the Liberal Arts office…and I said, "I wanna to change to Liberal Arts" and the girl said "Sign here." That was it. It was so anti-climactic, it wasn't even funny, you know? And I walked out and thought, "Well? Okay." And now I'm a Liberal Arts/Government major, by God! And so that's were I stand today.

These two stories were not the minority of switcher responses: thirteen out of sixteen switchers reported that found and selected their new major after they decided to leave biology, sometimes up to a year later. Five of these thirteen claimed an interest in their new discipline prior to switching, but only one had actually taken a college course required for that major prior to switching.[47] The remaining eight of these thirteen did not mention having any initial interest in their new major, and typically chose it as either a backup for medical school or because they excelled in the subject in high school. In the case of the former, one switcher explained his reasoning for choosing Accounting: "I guess I just thought of something that I could do in case medicine didn't work out and…it's the type of job…I thought I could do…you know, analytical work." In the case of the latter, another switcher clarified her reasoning for choosing English: "…I didn't

[47] The switcher who changed from biology to biochemistry to chemical engineering had taken introductory chemistry while a biology major. This course is also required of the other two majors.

realize where my real calling was until after I'd been an English major for awhile. I just knew it wasn't biology. I just really knew that that was not what I was gonna do, so…I thought, 'Well, just do some kind of liberal arts. You were good at English, just do that now.' And so that's what I changed my major to."

The remaining three of the sixteen switchers chose their new major as part of their decision to leave biology, though none of them reported that this other major was the reason they left. The first was a double-major and dropped the biology major around the time she decided against medical school (previously described). The second chose nursing instead of continuing as biology/premed because she still wanted to work in the medical field, but did not want, what she felt was, the difficult life of a physician: "…the reason I chose nursing was because it was a lot more flexible. I really wanted to have a family a lot more than I wanted a career." The last specifically chose psychology because her many biology credits transferred over to her new degree plan: "…all the classes that I've taken will transfer over into psychology very nicely and a minor in biology. So, even though I've taken more science than I need for psychology,…I have to minor in something and so I'm gonna minor in biology…I wouldn't have done it if I didn't find a major that was so easy to transfer into."

THE ROLE OF PERFORMANCE IN STAYING AND LEAVING

The final portion of this chapter describes the association between biology grades and reasons for either staying in or leaving the biology major. The section is divided into four parts: quantitative then qualitative analysis of grades versus persisters' reasons for staying; and quantitative then qualitative analysis of grades versus switchers' reasons for leaving.

Performance and Staying: Quantitative Results

Table 4.63 presents significant Spearman-rho correlations between persisters' reported biology grades and their reasons for staying in the major. Not surprisingly, eight out of the ten items most correlated with biology grade have to do with earning high grades or not having difficulties with coursework. The one item that was negatively correlated with biology grades was being discouraged from leaving the major. Although this item was not particularly important to persisters overall, this demonstrates that, at least for this portion of persister population, personal intervention is associated with persistence.

Table 4.63: Significant Correlations between Biology Grade and Reasons for Staying in the Biology Major (n=190) (in descending correlation order)

I have stayed in the biology major because:	rs	Sig.
I perform well in biology	0.502	0.000
Biology is easy for me	0.429	0.000
I do not have difficulty handling the amount of information I am expected to learn	0.377	0.000
I do not have difficulty handling the amount of work required in my biology courses	0.373	0.000
I do not have difficulty handling the pace of my biology courses	0.373	0.000
My talents are best suited to biology	0.352	0.000
I have performed better in biology courses than I did in other classes	0.325	0.000
I feel that I can succeed in biology	0.310	0.000
I feel that biology is right for me	0.298	0.000
I have a higher aptitude for biology than for other disciplines	0.295	0.000
I feel that I belong or fit in the biology major	0.279	0.000
I like my biology courses	0.238	0.001
I prefer biology over other disciplines	0.232	0.001
I am still interested in biology	0.217	0.003
I still like biology	0.211	0.004
Someone discouraged me from leaving the major	-0.210	0.004
I like the learning experiences that my biology courses have provided for me	0.198	0.006
The support I have received from my biology instructors	0.198	0.006
I like the way my biology courses have been taught	0.184	0.011
I am more interested in my biology courses than my other courses	0.174	0.017

Performance and Staying: Qualitative Results

In life story interviews, I asked persisters to describe how their performance played a role in their persistence in the major. Recall from Table 3.3 that four of the persisters were classified as higher-performing and three of the persisters were classified as lower-performing. Higher-performing persisters explained that their performance either had no effect on their persistence in the major or a confirmatory effect that they had chosen the right major. Two of the persisters with very high GPAs reported that their grades had nothing to do with their continuing in the major: "…I really don't think my performance really affected it…I could make A's and be miserable and I could make A's and be happy…" These kinds of responses make sense considering that these students made good grades in all of their classes, not just in biology, thereby providing them without a performance gauge to distinguish among disciplines. The other two students, however, explained that their good performance in biology confirmed that they had chosen the right major: "[My performance] just reinforces. Yeah, you're studying it, you're working hard and you're getting it and here are the results. If they're positive results, it just makes you like it even more… just positive reinforcement I guess." In addition, another persister explained that, had her performance been different, she may have not stayed in the major:

> I think, if I had not done well in my first two semesters in bio, it would have really made me reconsider a lot…Genetics was so hard for me because I was very interested in it, but I wasn't doing as well as I felt like I should have been doing. If that was the case my entire freshman year, and then also in Genetics, I would have stepped back and said, "Hey, maybe I enjoy this, but I'm obviously not good at it and this isn't something I should be majoring in." But I think, since I did so well in my bio classes my first year, I felt like this is something I can continue to do well in and that's how I feel now. I've had a hard professor in the past, but I feel like I have the ability to do well in biology and if I had started off not doing well, then I wouldn't have that confidence.

Lower-performing persisters explained that their performance either inspired them to try harder or had no effect on their persistence. Two of the participants who had below average performance in their biology courses explained that their performance had inspired them to keep going:

> 'Cause I've had not-so-good performance, it's made me want to do it more. I think, at the end, I'll have a much more rewarding college experience, as far as wanting to do or know in life. But not everyone does in…an English major or government major or something like that. [In one of those majors] I would have…had to study and it would've been hard at times, but not to the same extent that this is for me. Math and science [have] never been my strong suit, even when I was a kid, so deciding to make a career out of that is something that's challenging in itself. And even though, like anything else in life, I mean… times are hard, and learning to work through it as best you can is probably a really good thing to learn, and that's what I'm doing here, with my education.

Similarly, another persister explained that earning poorer grades than her classmates meant she should try harder so that she accomplishes her goals:

> …I actually do like biology, and I'm being discouraged and I shouldn't be, you know?…what's keeping me is…I just need to try harder,…fight for what I want, you know? It's just like all the other kids are doing, so I just can't be discouraged by others and…If I really want it, then I'm gonna have to really try hard and keep at it, you know?

The last lower-performing persister reported that her grades had little effect on her decision to stay in the major because she tended not to take her grades too seriously and because she did well enough to move onto the next course.

> …I got a C last semester and that was like my worst grade ever, but I wasn't really let down by it because, I don't know, I really…it didn't make me like hate biology or anything. It didn't make me hate my teacher or anything, so I was like, "Eh, okay, [Bio II] time, I passed!" And, so my performance…didn't really figure much into my decision to stay.

Whether their grades inspired them to continue, inspired them to try harder, or were not a consideration in their decision to stay in the major, it appears that the persisters did not use their grades as their primary evidence for whether they should persist. In fact, not

one of the persisters interviewed in the study reported their grades as the major reason for staying often noting it was a contributing factor. This may be due to the fact that all of the persisters, even the ones with 4.0 GPAs, reported struggling with one or more of their biology courses, as mentioned previously.

Performance and Leaving: Quantitative Results

Table 4.64 presents the significant non-parametric correlations between biology grades and stated reasons for leaving the biology major as recorded on the questionnaire. Noteworthy is that there were no positive correlation between grades and reasons for leaving biology, indicating that poor performance played a large role in switchers' reasons for departure.

Table 4.64: Significant Correlations between Biology Grade and Reasons for Leaving the Biology Major (n=106) (in descending order, continued on next page)

I left the biology major because:	rs	Sig.
I performed poorly in biology	-0.695	0.000
Biology was difficult for me	-0.616	0.000
I had difficulty handling the amount of information I was expected to learn	-0.572	0.000
I had difficulty handling the pace of my biology courses	-0.549	0.000
I performed better in other courses than I did in biology courses	-0.543	0.000
I had difficulty handling the amount of work required in my biology courses	-0.529	0.000
I did not like my biology courses	-0.461	0.000
I felt that I could not succeed in biology	-0.457	0.000
I grew to dislike biology	-0.455	0.000
I have gotten a better education my other courses than I did in my biology courses	-0.391	0.000
I did not like the way my biology courses were taught	-0.377	0.000
I felt that biology was wrong for me	-0.371	0.000
I was more interested in other courses than my biology courses	-0.346	0.000
I lost interest in biology	-0.340	0.000
The lack of support I received from my biology instructors	-0.336	0.000
I did not like the competitive nature of my biology courses	-0.329	0.001
I have learned more in my other courses than in my biology courses	-0.324	0.001
I found out I have a higher aptitude for another discipline	-0.316	0.001
I felt that I did not belong or fit in the biology major	-0.308	0.001
My other instructors were better or more effective teachers than ones in biology courses	-0.304	0.002

I left the biology major because:	rs	Sig.
It would have taken too much effort to finish a biology degree	-0.303	0.002
I did not like the way I was treated by my biology instructors	-0.294	0.002
I did not like the learning experiences that my biology courses provided for me	-0.288	0.003
The lack of support I received from my biology advisor	-0.263	0.006
Someone encouraged me to change my major	-0.262	0.007
The lack of support I received from my fellow biology students	-0.258	0.008
It would have taken too much money to finish a biology degree	-0.229	0.018
I preferred another discipline over biology	-0.226	0.020

Performance and Leaving: Qualitative Results

In life story interviews, I asked switchers to describe how their persistence played a role in their departure from the major. Recall from Table 3.3 that four of the switchers were classified as higher-performing and five of the switchers were classified as lower-performing. Similar to the higher-performing persisters, three of the four higher-performing switchers explained that their performance had little to do with their decision to leave, explaining instead that their good grades provided evidence that they should leave for something they were more interested in doing, and not just something in which they could succeed: "… I made A's in all my biology classes… and overall I'm a good student, so I don't think learning the material and taking the exams was a real problem. So, I guess…the grades didn't really affect the actual decision to leave. It was mainly about interest." The other higher-performing switcher explained that, because she felt her grades were not competitive enough, she questioned whether she should continued on her career path: "'cause I never got bad grades before, and I was getting them…I was like… 'I need a good grade… point average to get into a grad school program, or medical school…so should I stay in this major?' And so, a lot of the time, it would cause me to question it a little bit, at least." Interestingly, even though this persister made above average biology grades, she still perceived that her performance was comparatively poorer than those she felt were better suited to the major.

By contrast, the five lower-performing switchers reported that their performance was very important in their decision to leave. In all cases, these students explained that they viewed their poor performance as a sign that they were in the wrong major. Two of these lower-performing switchers left due to continued average or below average performance:

> Well, seeing that I wasn't doing well in the classes …I'm not a C student and I was getting C's in these courses. And it's like, "Something obviously is wrong…It's not working for me." I mean, coming out of high school, I had a 3.8 GPA and then, coming to college,…I'm not even anywhere near that. And I'm like, "It's not, it's not working for me, so I've had enough, I'm not doing it."

The other three lower-performing switchers described performing poorly in a particular course as the event led them to finally make the decision to leave the biology major:

> I dropped my [cell] biology class…I did bad[ly] on the first test, studied a little bit more, more than I've ever studied. Second test: did even worse. "That's it. I'm gonna use my Q drop and I'm gonna change majors." That was it…It was time. And I said, "Better now than never. This is the half-way point and it's time to do something about it 'cause I'm not happy. Even though I like the subject, I'm not happy and I'm not gonna do well when I come out if I'm not gonna do something about it."

The weight of these experiences was sometimes devastating, as one switcher explained of her freshman biology experiences:

> [My performance] was everything…After we finished [the first introductory biology course] and I think I got a C in the class, and then we started the next course and…we took…the first test of that course and I was still doing just as bad as I did on all the others…Even though I kept trying and trying…, I was just always making the same grades. I figured, "Maybe this is just not for me" you know?" But, at the time, I wasn't thinking maybe biology isn't my thing, I was thinking maybe college is not my thing…

Interestingly, I asked these five switchers about the thought process they underwent when deciding to leave the biology major, only one actually mentioned poor performance as part of the decision. Whether this is because they knew there would be an additional question specifically about performance, they were reluctant to discuss their performance,

or their performance operated through other parts of this decision, such as interest, is up for speculation.

SUMMARY

The chapter presented the results of this study, organized by chronological time periods: Precollege Experiences; Choosing Biology; Experiences in and Perceptions of the Biology Major; The Phenomenon of Staying; The Phenomenon of Leaving; and The Role of Performance on Persistence. The next chapter includes the synthesis and discussion of the major findings; a discussion of the data to Stage and Hossler's (2000) model; and a report of the areas of future research and recomme

Chapter 5: Discussion and Conclusions

INTRODUCTION

The purposes of this sequential explanatory mixed methods study were to: 1) explore the differences and similarities between biology switchers and persisters with respect to their pre-college and college experiences, including how they chose the biology major; 2) explore how performance and other factors play into persistence and departure; and 3) use the stories of biology switchers and persisters to understand how students make decisions regarding biology persistence and departure. This chapter is divided into four major sections: Summary, Integration, and Discussion of Major Findings; Comparison to Stage and Hossler's (2000) Student-Centered Theory of Persistence; Recommendations; and Areas for Future Research.

SUMMARY, INTEGRATION, AND DISCUSSION OF MAJOR FINDINGS

Organized in the same chronological format as Chapter Four, this section presents the eight major findings of this study, divided by relevant topic: Precollege Experiences and Sources of Encouragement; Choosing the Biology Major; Experiences in and Perceptions of the Biology Major; Staying in the Biology Major; the When and Where of Switching; Student Demographics Associated with Switching; Leaving the Biology Major; and the Role of Performance in Staying and Leaving. Included within the discussion of each finding are supported evidence and references to relevant data from prior studies.

Finding One: Precollege Experiences and Sources of Encouragement

Regardless of their eventual major, biology students enter college with the same suite of precollege experiences and personal sources of encouragement informing their interest in biology (Tables 4.1 through 4.14).

Precollege Experiences

As shown in Tables 4.1 through 4.9, there were virtually no differences between switchers and persisters in the types, number or overall importance of the precollege experiences that developed their interest in biology. As seen in both questionnaires and interviews, the two most important experiences informing biology students' interest were their high school biology experiences and educational television. First, a clear majority (over 85% each of persisters and switchers), reported their enjoyment of and performance in high school biology were important in developing their interest. Moreover, all of the life story interview participants described these high school experiences as foremost in their later interest.

Second to high school biology, over three-quarters of questionnaire and approximately one-half of life story interview participants reported that educational television was important in developing their interest in biology, which Strenta and colleagues (1994) found is more common among biology majors than students in other disciplines. This importance is a direct reflection of the prevalence of biological and medical topics covered on television, particularly cable, and an indication of where many students obtain information about biology and potential careers.

The most revealing finding among these results was that, regardless of their eventual major, life story interview participants had generally positive high school biology experiences and poor or unremarkable high school chemistry and physics experiences (Table 4.8). Because of this trend, it is unknown how much of participants'

interest in biology was due to their experiences in biology and how much of it was due to their lack of interest in their other coursework, most notably chemistry and physics.

Sources of Personal Encouragement

As shown in Tables 4.10 through 4.14, biology switchers and persisters were also very similar in terms of the persons who encouraged their interest in biology during their precollege years. As evidenced in both the questionnaire and later interviews, the two groups of people who most encouraged students' interest in biology were high school biology teachers and particularly parents. As shown in questionnaire results, for example, over 82% of persisters and 77% of switchers rated their high school biology teachers, and over 75% of persisters and 70% of switchers rated one or both of their parents as encouraging their interest in biology, a trend repeated in life story interviews. Interestingly, there was little evidence that encouragement from parents and teachers was a result of participants' earning good grades in their science courses. Overwhelmingly, participants described these adults as supporting their curiosity and providing them with opportunities to mold their interest in science, in effect allowing them to be children and scientists simultaneously.

Finding Two: Choosing the Biology Major

Regardless of their eventual major, biology students had similar reasons for choosing the biology major. Where these groups differed is attributable to data contamination. The major reasons participants chose biology were: their high school experiences; their parents; medical school; and the appearance of and job options connected to the biology major (Tables 4.16 through 4.23).

High School

Based both upon quantitative and qualitative results, a significant portion of participants chose the biology major based upon their high school experiences. As mentioned in "Finding One," participants reported that their high school experiences helped develop their interest in the discipline and high school biology teachers encouraged that interest. In terms of major choice, these relationships were far more nuanced, with both direct and indirect references to high school experiences as the basis of their choice. Direct references included: 1) qualitative descriptions of high school as their reason for choosing biology, which at least three-quarters each of persisters and switchers mentioned and 2) agreement with high school specific statements on the questionnaire, such as: "I did well in high school biology." Indirect references included: 1) qualitative descriptions of interest in biology or lack of interest in other disciplines and 2) agreement with statements alluding to said interest on the questionnaire, such as: "Biology was easy for me", "I thought biology was the most interesting of the sciences," and "It seemed like the best choice based upon the options available to me." Due to the fact that most[48] questionnaire participants had declared the biology major before the first semester of their freshman year, these descriptions and statements are a greater reflection of participants' academic interests, perceptions of biology, and understanding of their options during high school than those developed in college. For example, choosing biology because it is fun (84% of persisters and 71% of switchers) or easy (62% of persisters and 52% of switchers) sounds more appropriate to descriptions of high school biology than introductory biology, particularly at The University. In light of these connections, high school experiences informed participants' major choice in four ways,

[48] Recall from Chapter 3 that only 11 out of the original 319 participants switched from undeclared natural sciences to biology during the first semester of college. The rest began their education in the biology major.

through their: performance in biology, interest in or enjoyment of biology, lack of interest in other disciplines, and ignorance of other available options.

Performance in Biology. Based upon questionnaire responses, 72% of persisters and 69% of switchers rated performance in high school biology as important to their choice of biology (Tables 4.16 and 4.17). There was no significant difference between switchers and persisters in terms of the importance of high school biology performance and their choice of the major. In contrast, Seymour and Hewitt (1997) found that persisters were more likely than switchers to mention high school performance as a reason for their choice. Though the source of this incongruence is unclear, it is likely due to the fact that not all STEM disciplines are represented at the high school level and, because Seymour and Hewitt (ibid.) did not control for the percentages of persisters and switchers derived from each discipline, the effect of high school performance could be highly variable depending on which STEM majors each group represented.

Interest in and Enjoyment of Biology. For switchers and persisters, interest in and enjoyment of biology was important to their decision to choose biology as a major. As shown in Tables 4.16 and 4.17, liking biology (93% of persisters and 72% of switchers); biology being the most interesting of the sciences (93% of persisters and 67% of switchers); wanting to learn more about biology (92% of persisters and 77% of switchers); and interest in anatomy and physiology (73% of persisters and 72% of switchers) formed some of the most significant reasons that participants' chose the biology major. In interviews, almost three-quarters of persisters and half of switchers described interest in biology as a reason for their choice (Table 4.22). Obvious in these responses is the difference in agreement between persisters and switchers. Overall, persisters were more likely than switchers to have chosen biology as a major out of

interest or enjoyment (Tables 4.18 and 4.22), a result supported by Manis and colleagues (1989) and Seymour and Hewitt (1997).

On the outset, the difference between switchers and persisters highlights a potential precondition for switching: if a student is less interested in a discipline from the beginning, s/he is more likely to leave. However, I contend that differences in interest between switchers and persisters are inflated due to the *ex post facto* nature of the study. Because there were virtually no initial differences between switchers and persisters in terms of their demographics, precollege experiences, sources of encouragement, and number of high school biology courses undertaken (results reported later), it is not likely that they entered college with different levels of interest in the major. Rather it is likely that some portion of persisters overstated their initial interest in or enjoyment of biology because they currently find biology to be interesting or enjoyable; and that some portion of switchers understated their interest in or enjoyment of biology because they currently find biology to be uninteresting or unsatisfactory.

Lack of Interest in Other Disciplines. As mentioned in "Finding One," participants' initial interest in biology was probably enhanced by their lack of interest in other disciplines, namely other sciences taught at the high school level. That so many persisters and switcher reportedly chose biology because they thought it was the most interesting of the sciences implies that a significant portion of these biology students believed their other science courses were or would be less interesting. In addition as seen in interviews, over half of persisters and one-quarter of switchers interviewed named their lack of interest in other disciplines as a reason for their choice of the biology major (Table 4.22).

These results demonstrate that at leas part of the decision-making process involved in major choice is one of process of elimination. As described in interviews,

participants eliminated non-science disciplines, usually due to a lack of interest, unsure job prospects, or appearances (described later); they eliminated other science disciplines, largely due to poor or unremarkable high school experiences; and they chose biology, partly because of interest and partly because it was the only remaining option. Even more important was that participants' decreased interest in high school chemistry and physics often carried-over into college, in effect confirming that their choice of biology was correct, at least in the short term. Evidence of this continued disinterest in or dislike of chemistry and physics is demonstrated by the minuscule number of undergraduates who switched from biology to the chemical and physical sciences, with 3.9% of switchers transferring to chemistry or biochemistry and 0.2% of switchers transferring to physics (Table 4.56).[49]

Ignorance of Other Options. The sum of their high school experiences, coupled with participants' poor understanding of their options, further confirmed that biology was not only reasonable, but the only viable option. Although not the main reasons that either persisters or switchers chose the major, that a significant portion of interview participants (half of persisters and one-quarter of persisters) reported choosing biology because they did not know what to major in and, on the questionnaire, 68% of persisters and 70% of switchers reported choosing the biology major because it seemed like the best choice based upon available options, is further evidence of the role of high school in these decisions (Tables 4.17, 4.18, and 4.22). Though this is considerably more than Seymour and Hewitt's (1997) finding that 9% of switchers made an uninformed choice, a likely result of the inclusion of STEM majors unavailable in high school in their study, it speaks to the naïve logic undergraduates use when choosing biology. If a student is only

[49] For chemistry, this is 23 out of 592 total switchers; for physics, this is 1 out of 592 switchers. If only considering switchers who transferred to other STEM majors, this accounts for 13.0% (23 out of 177) transferring to chemistry and 0.6% transferring to physics (1 out of 177).

exposed to a subset of disciplines a the high school level and these form the only real academic experiences the student has, then the choice of what is known or familiar is the only logical choice. These reasons, coupled with the premature elimination of other options because of a lack of interest or enjoyment (above) or the appearance of the discipline (below), ensure the viability of biology as the only choice, despite that choice being patently uninformed. Interestingly, in this study, switchers were more likely than persisters to admit or characterize their choices as ones made out of ignorance. Because both switchers and persisters made uninformed choices and a few of the persisters never had second thoughts about their major choice, this is less likely a factor predisposing departure and more a reflection of switchers' reevaluation of their initial choices as part of their decision-making process.

Parents

Whether participants' parents pressured their choice of science or the medical field, supported their interests in science, or provided a model for future career pursuits, over half each of switchers and persisters interviewed described choosing biology, in part, due to their parents' involvement (Table 4.22). While both persisters and switchers were similar in terms of parental support, there was a difference in terms of pressure and modeling. Switchers were more likely to characterize their parents as pressuring them to do science or work towards medical school, which, for some, was a factor in their eventual departure. Conversely, persisters were more likely to characterize their parents as models (examples or anti-examples) for potential careers. Seymour and Hewitt (1997) named this latter reason following a family tradition and labeled it as an uninformed choice. In this study, however, there is little evidence that choosing biology based upon parental modeling was a "blind" choice. First, participants who discussed their parents as models had learned a lot about their parents' careers, either through their parents or

relevant volunteer opportunities that that serviced the same career. Second, because they found their parent's job unattractive or felt their parent had settled for rather than chosen a career, participants more often wanted to do the opposite of their parent.

Interestingly, the importance of parents was not duplicated on the questionnaire: although both switchers and persisters rated their parents as very encouraging of their interest in biology (Finding One), the items that indicated parental involvement in major choice had comparatively lower ratings by both groups (Table 4.19). Beyond sample size differences between the questionnaire and interviews, this discrepancy could have been caused by a semantic defect in the questionnaire, whereby the statements about parents were not appropriate to the reality of parental involvement, as found in interviews; or by the comparison implied by the questionnaire, whereby participants tended to rate these statements as with a rating of one because they were comparatively less important than other reasons, such as interest. This latter reason hints at the power of the chronology integral to life story interviews: the role of parents may have been enhanced in interviews because participants were thinking through the process of their choice of biology, rather than being asked to rate the importance of randomly-ordered statements. Even with this discrepancy, the questionnaire items concerning involvement of parents did highlight a significant difference between the participants who switched to STEM and those who switched to non-STEM majors: non-STEM switchers were more likely than STEM switchers to report choosing biology to please their parents, or because their parent or other significant adult wanted them to work in a health profession or major in biology. These differences hint at one potential reason why more students leave for non-STEM majors than STEM majors: non-STEM switchers may have had less involvement in their choice of biology from the start (Figure 4.2 and Table 4.55).

Medical School and Helping People

Whether they chose biology because: 1) it was the default choice for medical school, 2) they believed it would best prepare them for medical school, or 3) the requirements for premed and the biology major coincided, half each of switchers and persisters interviewed chose biology, in part, because of their desire to go to medical school (Table 4.22). On the questionnaire, in terms of being important to their choice of the biology major, approximately 77% of persisters and 82% of switchers reported their desire to work in the health professions; 62% of persisters and 75% of switchers reported biology as the best degree to have for professional school (medical, dental, veterinary, pharmacy, etc.); and 56% of persisters and 68% of switchers reported the need for biology for preprofessional educational requirements. In addition, 81% each of persisters and switchers reported that they chose biology because of a desire to help people (Table 4.16 and 4.17). As described in interviews with both switchers and persisters, this latter desire primarily revolved around working in the health professions as well. Despite its inherent logic, the connection between helping people and being a doctor again highlights students' limited exposure to or knowledge of the variety of options available to them. Though Seymour and Hewitt (1997) found that only 2% of participants reported this as a reason for a STEM major choice, this difference is likely result of their conflation of all STEM disciplines, particularly since "helping others" is so often associated with being in the medical field and medicine is so often associated with majoring in biology.

Appearance and Job Options: The Switcher-Persister Dichotomy

In interviews, one salient difference between switchers and persisters was that a third of the switchers chose biology for appearance reasons, whereas a third of the persisters chose biology for the job options connected to it (Table 4.22), reasons somewhat suggestive of Seymour and Hewitt's (1997) pragmatism/materialism reasons

for choosing STEM majors. Additionally, each of these reasons seemed to be an offshoot of their parents' involvement in their education. Whether they wanted a respectable major (science rather than non-science) or one that would allow them to have a reasonable career, many of these participants' responses suggested familial pressure as part of their reasoning. While it is interesting that switchers and persisters voiced their concerns so differently, this is probably due to contamination. Evidence for this is that all four of the persisters who mentioned choosing biology because of future job options also later reported these as reasons for continuing in the major. Furthermore, while it is entirely likely that some portion of persisters initially chose biology because it looked good, it is less likely that they would admit that when considering other reasons for their initial and continued commitment to the biology major.

Despite the problem of contamination, these differing emergent themes highlight potential contributors to departure and persistence. First, that only switchers reported appearance of the major to others (usually parents) provides additional evidence that some portion of switchers were in the major for a wrong reason: to service others' rather than their own interests. If an inauthentic reason for choosing biology, such as appearance, is not superseded by reasons more authentic to the discipline itself, then this may predispose departure from the major. Evidence for this is that all but one of the participants' who reported appearance as a reason for choosing biology over some other discipline, ended up leaving biology for the discipline they originally avoided. Secondly, that only persisters reported choosing biology because of the perceived job options connected to the major provides evidence that some portion of persisters were in the major for a right reason: to service more short-term rather than long term goals. As demonstrated in interviews and hinted at in the questionnaire, persisters' were more focused on immediate concerns, such as satisfying their interest in the discipline, and

short-term career goals such as finding employment or getting into medical or graduate school, whereas switchers were more focused on long-term, sometimes nebulous, career goals, such as becoming a physician or marine biologist (for example). That a more narrow focus is associated with persistence makes sense considering that a student must accomplish immediate and related goals to maintain momentum towards a long-term goal.

Finding Three: Experiences in and Perceptions of the Biology Major

As indicated in their lower ratings of different aspects of the biology major on the questionnaire and their descriptions of experiences in the biology major, switchers had generally poorer opinions of and experiences in the biology major than persisters and these poor experiences lowered their commitment to their original choice of major (Tables 4.24 through 4.41).

First Year Experiences

Based upon interviews, negative introductory biology experiences, particularly in the first semester, were predictive of departure and positive introductory biology experiences were predictive of persistence (Table 4.30).[50] This finding is supported by survival data showing that the greatest proportion of students leave after their freshman year; and Manis and colleagues (1989), who found that switchers reported their first year science experiences as most influential in their decision to leave the major. In addition, that so few of the switchers had taken upper division biology courses, widely described as "favorite" courses by persisters indicates that switchers may have left the major largely due to experiences not representative of the biology major. Complicating this is that

[50] Recall that differences in persister and switcher experiences were not necessarily a product of which instructor they had, since a few of the persisters and switchers had exactly opposite opinions of the same course and faculty member.

since neither persisters nor switchers had particularly positive experiences in introductory chemistry, often taken concurrently with biology, there is also evidence that poor chemistry experiences had opposing effects on switchers' and persisters' persistence in the major. For switchers, poor chemistry experiences tended to provide further confirmation they should leave biology, whereas for persisters, poor chemistry experiences tended to provide confirmation they should not leave biology, i.e. that they were not chemistry majors.

Despite the erroneous implications that students should have to endure introductory courses to take the more interesting courses, it does highlight potential area for improvement, not only in terms of instruction (discussed in the recommendations) but also in terms of marketing. Freshmen may benefit from reminders from their instructors that 1) introductory coursework is not necessarily indicative of upper division coursework in the biology major, and 2) that there is some amount of "trudging through" students should expect in any major, including biology. Based upon interviews, this was common knowledge among all of the persisters and only three of the switchers, each of whom left biology after their sophomore year and had taken more than one upper-division biology course.

Experiences with Advisors

Although advisors were relatively insignificant with respect to persistence and departure decisions, there was a trend, apparent among interviews, in which switchers had primarily negative advising experiences and persisters had both positive and negative advising experiences (Table 4.35). The timing of these experiences seems critical, with most negative experiences occurring during participants' earlier education and positive ones occurring later. Whether this is due to the differences in the types of advising sought by freshmen versus upper-class students or due to differences in the way advisors

regard these two types of students is unclear. Regardless, it appears that most switchers were not in the major long enough to have good advising experiences, and this, albeit minimally, contributed to their departure from the major.

Thought the purpose of this study was not to uncover what biology students find unsatisfactory about advising, these complaints, which mirror those found by Seymour and Hewitt (1997), enlighten areas in which at least some portion of biology students are underserved. First, as described by both switchers and persisters, a common complaint of biology advisors was that they offered generic advice, most of which came in the form of "what most biology students do," or the prescribed degree plan. Somewhat related to receiving generic advice was that several of the switchers reported feeling as though their advisors treated them like a number. This most often involved being rushed through the advising process and not feeling heard when they sought advice about coursework and academic difficulties. In addition, both switchers and persisters described instances in which their advisors lacked knowledge or gave them faulty advice, which in this study, most often resulted in students taking the wrong class or obtaining unclear information about their progress to degree. All of these complaints were, as many of the participants pointed out, a consequence of a handful of advisors assigned to a large number of biology students. Interestingly, switchers found this to be less of an acceptable excuse than persisters, primarily because many had better advising experiences in their new and much smaller majors.

Experiences with Faculty

Based upon quantitative comparisons of switchers' and persisters' opinions of instructors, including their courses and teaching, switchers had much lower opinions of biology faculty than switchers (Tables 4.24 and 4.25). Moreover, where persisters rated biology teachers as encouraging their interest in biology at a level similar to their parents,

switchers rated college biology faculty as most discouraging of all precollege and college personnel (Tables 4.10, 4.31 and 4.32). The difference between these ratings produced one of the largest effect sizes emerging in the study (Table 4.33).

As gathered from interviews, it was apparent that switchers' lower opinions of faculty were a result of the generally poor behaviors exhibited by faculty in the classroom and switchers' fewer out of class contacts with faculty. In effect, instructors' in-class behavior discouraged these switchers from approaching them outside of class, and this further cemented their perceptions of faculty as indifferent, unwelcoming, uninspiring and exacting, for example (Table 4.38 and 4.39). This finding is partially supported by Packard's (2005) claim that persisters were more likely to report initiating mentoring relationships than were switchers. Packard (2005) found in her study of 79 science switchers' and persisters' perceptions of barriers to mentoring in science, that although there were not differences between groups in terms of access to mentors or fear of approaching potential mentors, there was a significant difference between these groups in terms of students' ability to initiate mentoring. In this study, only two of the switchers, both of whom worked in biology laboratories, had formed significant relationships with at least one biology faculty member, whereas almost all persisters had.

On the other hand, persisters more often described faculty in positive terms, which was a direct reflection of not only their greater contact with faculty outside of class, but having more working relationships with faculty (in the lab or field). However, since less than half of persisters included descriptions of biology faculty as being engaging, caring, welcoming, knowledgeable, or student-interested, it appears that these qualities were more the exception than the rule among biology faculty (Tables 4.38 and 4.39). Further supporting this is that one-quarter each of switchers and persisters labeled faculty as more research- than teaching-oriented (self-interested versus student-

interested). This is supported by Seymour and Hewitt (1997) who found that 90.2% of switchers and 73.7% of persisters complained about poor teaching of STEM faculty, most often attributing it to instructors' greater concern about research. How persisters learned to cope with difficulties with faculty is poorly understood, but qualitative data suggests that, while switchers tended to ascribe the poor behaviors exhibited by a few instructors to all biology instructors, persisters tended to disregard these poor behaviors as aberrant. As with advising experiences, this is likely a reflection of their time in the major: they were in biology long enough to have more positive than negative experiences with faculty.

Experiences with Peers

Based upon interviews, participants' perceptions of their peers were most important in their eventual departure or persistence in the major. Switchers and persisters differed in two areas connected to peers: the kinds of relationships they had with their peers and how they were affected by the competitive behavior or their peers.

Relationships. There were three types of peer relationships described by interview participants: partnerships (studying with peers), friendships (socializing with peers), and comradeships (identifying with peers. Although persisters and switchers reported studying with other students at about the same rate, persisters were more likely to mention having friends within the major as well as being able to identify with other students in the major (Table 4.41). Also noteworthy is that persisters more often described group study as studying with friends, while switchers more often described group study as studying with "other students." Though not supported by these findings, Seymour and Hewitt (1997) found that the lack of peer study support accounted for 9% of switching decisions, noting that study groups were integral to students feeling as if they were part of a group.

That group identification in this study was formed largely via friendships and comradeships, rather than partnerships indicates that loneliness, for lack of a better term, is associated with departure. Supporting this finding is that, through regression analysis of the association of environmental with outcome measures including final choice of the biology major, Astin and Astin (1993) found that having a large number of friends in the discipline predicted persistence in the major. In addition, Brooks (2007) found in her qualitative study of college students' perceptions of the nature of their friendships and their impact on academic and non-academic activities that: "…most students claimed that the sympathy, understanding and general encouragement offered by friends at times of difficulty or stress had enabled them to persevere with their studies and, ultimately, complete their degree. (p. 697)."

Competition. Competition was a major theme of interviews, with persisters complaining more about it than did switchers. This trend was previously demonstrated by the finding of Strenta and colleagues (1994) who found that biology students rated their courses as more competitive than students in other disciplines, including engineering and physics. As gleaned from interview responses, the likely source of this competition was due to premedical students, as similarly found by Seymour and Hewitt (1997). However, switchers and persisters attributed these behaviors to different groups of students: where switchers more often attributed this behavior to "other students," persisters more often attributed this behavior to premed students, a discrepancy that points to the possibility that switchers misidentified despicable premed behaviors as biology student behaviors. Moreover, in this study, competition seemed to be more of a complaint among women than men, a finding supported by both Manis and colleagues (1989) and Seymour and Hewitt (1997). While this does not imply that men are unbothered by this competition, the differential effect of competition between women and

men may be one explanation for the generally lower survival of women in STEM majors overall.

More important than the complaints about or sources of competition were its effects, which largely centered on feelings of separateness (Table 4.40). The most negative of these, feelings of inadequacy and exclusion, were primarily reported by switchers, and typically formed the basis of beliefs of poor fit with or not belonging in the biology major. These types of reactions were amplified for switchers who were part of a cohort group, in which there seemed to be loss or lack of group identity due to the competition. While both switchers and persisters mentioned leaving the premed track due to competition, persisters were more likely to report avoiding participation in organizations or departmental functions that included premed students. This difference may hint at one of Seymour and Hewitt's (1997) coping strategies: where switchers may be more likely to suffer because of competition, persisters may be more likely to avoid the situation altogether. This difference also highlights an unintended consequence of competition: if an effective way to deal with the competitive atmosphere is non-participation, which reduces a student's involvement within their major, then non-participation could technically increase the risk of departure. Since these same persisters had other ways to be involved, primarily working in the field, it is likely that these other activities compensated for their non-participation in organizations or other biology department functions.

Finding 4: Staying in the Biology Major

Persisters do not actively decide to stay in biology; rather they simply do not, and in some cases refuse to, leave. There are three often interacting sources of this "not leaving" phenomenon: 1) based upon both the questionnaire and interviews, since so many reported continued interest in biology or a career stemming from it, some portion

of persisters have not left simply because they happened to choose the "right" path from the start; 2) based upon interviews, although many persisters have had both second thoughts about continuing in the biology major and have had sufficient reason to leave the major at one time or another, they stayed because their other options seemed less worthwhile or because they did not want to quit; and 3) based upon both questionnaires and interviews, having a sense of place or belonging confirmed persisters' choice of biology as a major (Tables 4.43 through 4.49). As collected from both qualitative and quantitative results, the most significant reasons persisters stayed in the biology major were: interest and enjoyment; not wanting to give up or give in; having other "stuff to do;" belonging or fitting in; and good performance in biology courses.

Interest and Enjoyment

Although coded separately in interviews because there was not strict overlap, interest and enjoyment each accounted for 90% of questionnaire participants' reasons for staying in the biology major (Table 4.47). Similarly, approximately three-quarters of interview participants reported that they stayed in the biology major out of interest or enjoyment (Table 4.48). In addition, a significant portion of questionnaire participants reported staying in the biology major because they liked their biology courses (84%); they preferred biology over other disciplines (75%); they were more interested in biology courses than other courses (76%); and they liked the way their biology courses have been taught (54%).

Like high school experiences and as demonstrated in interviews, the majority of persisters' interest in biology was cultivated through their college biology experiences, including their work in biology, course experiences, continued interest in the career connected to biology, and lack of interest in other disciplines (Table 4.48). In the first case, although several participants noted frustration associated with doing research (i.e.

not getting results, etc.), all of the persisters working "in-field" noted how it both enhanced their interest in and commitment to biology, a finding supported by Astin and Astin (1993). In the second case, particular course experiences also functioned to sustain persisters' interest and enjoyment, sometimes at a critical juncture when the participant was contemplating changing majors. In the third case, as mentioned above, a significant portion of questionnaire participants and a smaller proportion of interview participants stayed in the biology major, in part, because of job options and future career plans, including doing important work after graduation. Lastly, mirroring the effect of high school experiences, a lack of interest in other disciplines accounted for almost one-third of interview participants' reasons for staying in the biology major.

Not Wanting to Give up or Give in

The most popular reason for staying in the biology major among interview participants was a desire to not give up or give into the difficulties inherent in the discipline. Whether this was expressed as not quitting or in more defiant terms, I was quite surprised that this reason was mentioned more often than enjoyment and interest. In addition, four of the persisters noted that they never considered leaving, even though all had setbacks during their time in the biology major.

There are two pieces of evidence from registrar and questionnaire data supporting the primacy of not giving up among persisters. 1) Approximately 58% of students graduating with a biology degree start college in the biology major and 48.6% do not change their major even once during their education. This is supported by Astin and Astin's (1993) finding that the most significant predictor for final choice of the biology major (i.e. persisting) was freshman choice of that major. 2) Even though 51.4% of those initially-committed biology students change their major at least once during their education, these changes are primarily to other biology majors and not to other

disciplines and back to biology. That so few changes were made is indicative of the prominence of this "stay the course" reasoning among the interview participants. 3) Considering over 75% of questionnaire participants reported that they stayed in the major because they were still interested in a career or profession for which a biology degree is helpful or required indicates that unchanging career aspirations probably figure into "not giving up" in a meaningful way. Again, Astin and Astin (1993) showed that a significant entry characteristic predicting final choice of the biology major was aspiration to one of the following fields: research scientist, scientist-practitioner, or farmer/forester, with science-practitioner (including the medical field) having the greatest correlation.

Having Other "Stuff to Do"

An interesting super-code emerged from persisters qualitative descriptions of their decision to stay in biology, that of having other activities outside of their biology coursework with which to concern themselves. Often linked to a "stay the course" response, whereby persisters explained they had little time to worry about their level of satisfaction with their biology experience, because they were so busy, nine of the persisters described staying in the biology major, in part because they were able to satisfy their non-biology interests while still pursuing a biology degree. Whether this was by double-majoring with a non-science degree, pursuing a BA rather than a BS degree, switching to and from another major during their education, or taking a significant amount of non-science coursework during their freshman year, the effect was that these persisters were not fully "bio-directed" as one persister called it. In addition, two other persisters mentioned that their work in the biological sciences allowed them to not "obsess" over their academic life. Together, these indicate that, whether diverted by a job or by other intellectual pursuits, for over half of the persisters interviewed, doing more than just taking science courses was part of the reason they were still biology

majors. In light of the fact that so many of the persisters and switchers lamented about the heavy course load in biology, persisting because you have even more to do is rather counterintuitive. However, it makes sense when considering how many switchers were concerned that the workload associated with the biology major amounted to giving up their other interests. Because these persisters took the courses they wanted to take, sometimes against the advice of advisors, they did not necessarily have to make those kinds of accommodations.

Belonging or Fitting In

Based upon both questionnaire and interview responses, belonging in the biology major and believing biology was the right major were considerably important to persisters' reasons for staying. As shown in questionnaire responses, 80% of persisters reportedly stayed because they felt that biology was right for them and 79% stayed because they felt that they belonged or fit in the biology major (Table 4.47). As seen in interviews, much of this sense of belonging was due to persisters' relationships with their peers. Interestingly, though not all of the persisters had friends in the biology, they all had support systems both in and outside of the classroom. Whether this support system included knowing they were "in the same boat" with their classmates, studying with other students, forging relationships with faculty or peers, or working with faculty and other students in the lab or field, all of the persisters had a sense of place regarding biology. In addition, strengthening the sense of belonging is that almost one-third of the persisters interviewed reported that they stayed in the major due to personal encouragement. Because the majority of this encouragement came from peers, this likely reinforced persisters' identity as part of a group, thus making biology seem like an even better fit.

Good Performance

Based upon interview and questionnaire responses, overall, good performance in biology was an important reason for staying in the biology major; often offering confirmation of an appropriate choice of major and further supported the "not leaving" phenomenon. For example, persisters reported staying because they felt they could succeed in biology (74%); performed well in biology (67%); had a higher aptitude for biology than for other disciplines (61%); they did not have difficulty with the pace of biology courses (58%); and they did not have difficulty with the amount of information expected to be learned (53%). Important in these results is the progressively lower percentages of agreement, the source of which is, based upon interviews, all of the persisters, regardless of grades, reported having difficulties in one or more of their biology courses.

Finding Five: The When and Where of Switching

Initially-committed biology students are most likely to depart during the second through fourth semesters of college and more often leave for non-STEM majors than other STEM majors (Tables 4.50 through 4.52; Figures 4.1 and 4.2).

First, based upon survival data (Table 4.50), 49% of those who leave do so during semesters two and three and 82% of those who leave do so during the first two years of their biology education.[51] As mentioned in Chapter Four, these semesters correspond to particularly heavy coursework for the typical biology major (those following the degree plan or health professions track). During the first year, students often take one year each of introductory biology, introductory chemistry and calculus. During the second year, students are often taking one year of organic chemistry and one or more upper division

[51] Note that it was not possible to find out what proportion of students leave the major before the second semester because student major is recorded at the end of each semester, rather than the beginning.

biology courses, including Genetics (usually taken during the first semester). The greater departure of students during these semesters holds true for switchers, irrespective of gender, ethnicity, generational status, initial degree sought, or eventual major (STEM or non-STEM).

Second, as mentioned previously, switchers more often leave biology for non-STEM disciplines than STEM disciplines (Table 4.55). Based upon the information in Tables 4.55 and 4.56, switching to Liberal Arts appears to be well-traveled among non-STEM switchers and lateral moves into Human Development and Family Science and Nutrition appear to be well-traveled among STEM switchers. Though there were few differences among non-STEM and STEM switchers in terms of their choice of biology (reported earlier), there were some notable differences in terms of their reasons for leaving biology, which again hints at the differences in proportions leaving for STEM versus non-STEM disciplines. As seen in Table 4.58, STEM switchers were more likely to report having better job opportunities in another discipline, a finding supported by Strenta and colleagues' (1994). Instead, non-STEM switchers were more likely to leave the biology major because of difficulties with their biology instructors, biology classmates, the pace of their biology courses, and greater interest in their non-biology coursework. This highlights another potential reason why STEM switchers persist at higher rates than non-STEM switchers: while STEM switchers leave for other pursuits, non-STEM switchers leave to escape biology.

Finding Six: Student Demographics Associated with Switching

Based upon survival analysis and Cox regression analysis, the entry demographic characteristics that increase biology students' risk of departure are being African-American, Latino/a, a White woman, or a woman seeking a Bachelor of Arts degree. The entry demographic characteristics that decrease the risk of departure are being Asian-

American, a White man, or seeking a Bachelor of Science, pre-health professions degree (Figures 4.3 through 4.5 and Tables 4.53 and 4.54). First generation status had no effect biology students' eventual departure or persistence in the major.

Gender

In terms of gender, women were more likely to leave than men, but this difference was largely due to the differential survival of white women and men. Interestingly, the efflux of white women is not primarily for non-STEM majors, as Strenta and colleagues (1994) found. Based upon registrar data, 31.9% of white women and 30.0% of white men switch to non-STEM majors, while 15.7% of white women and 9.4% of white men switch to other STEM majors. Recall that the largest proportion of switching from biology to other STEM majors is to nutrition and human and family development, so the efflux suggests more lateral moves than ones to "harder" mathematics-heavy sciences.

Ethnicity

Supported by findings from Seymour and Hewitt (1997) and Smyth and McArdle (2004), Asian-American students are more likely to persist than White students and White students are more likely to persist than both African-American and Latino students. The source of the difference between Asian-American and White students is largely a function of gender, with Asian-American women surviving at the same rate as White and Asian-American men, and White women surviving at a significantly lower rate. The source of the difference between Whites and African-American and Latino students was irrespective of both gender and generation. Despite continuing evidence of increased departure among African-American and Latino students, there is a bit of good news in these statistics. Based upon the percentages of African-American and Latino students among biology freshmen and biology graduates, as compared to the larger

populations of freshmen and graduates, these students are not technically underrepresented in the biology major. The loss of these students during college is being offset by enough switch-ins that the percentage of African-Americans and Latinos among biology graduates is consistent with the larger population of graduates.

Generation

In terms of generation, surprisingly, there was no difference in the survival of first generation and traditional college students. This goes against most published research regarding college retention (Ishitani, 2006) and provides some evidence that having college educated parents has little effect on persistence in science majors. A clue as to why can be gleaned from interviews: several participants, primarily persisters described their non-college educated and their non-STEM degreed parents the same way, as "not getting it."

Degree Sought

In terms of degree sought, there is evidence that seeking a BS degree is associated with persistence, whereas seeking a BA degree is associated with drop out. However, this relationship is complicated both by gender and health professions area. Women initially pursuing a BA degree are less likely to survive than their male or BS degree-seeking counterparts. In addition, BS degree seekers initially interested in health professions were more likely to survive than other students. There are two potentially interacting reasons for the greater survival of BS degree seekers: 1) academic goal-orientation (BS versus BA) and/or professional goal-orientation (health professions versus none or other) enhances persistence, the latter of which is supported by Astin and Astin (1993); 2) dissatisfaction with the BS has multiple outs, whereas dissatisfaction with a BA only has one, evidence for which from registrar and interview data. Although

approximately half each of biology graduates earned BA and BS degrees (56.9% and 43.0%, respectively), there was a major shift from the BS to the BA degree during the years they enrolled. When looking at those who completed a biology degree, three times as many BS degree seekers switched to BA degrees (39.9%) as did the reverse (13.4%), $x^2=228.954$, $p<0.001$, $df=1$. As seen in interviews, this switch seemed to be instigated by a desire to prevent science burnout or to explore other disciplines in addition to earning a biology degree. The prevalence of these switches may be a key as to why BS degree seekers are more likely to persist than BA degree seekers: in terms of difficulty, a BS degree is two steps away from leaving the major and the BA degree is only one step. If a student has difficulty with or dislikes the requirements of BS degree there are other options, a different BS or the BA; however, if a student has difficulty with or dislikes the requirements of a BA degree, the only realistic option is to leave biology altogether.

Finding Seven: Leaving the Biology Major

Switchers leave biology largely due to dissatisfaction with the biology major and not because they are pulled towards more attractive disciplines. The evidence for this is three-fold: 1) based upon registrar data, the greatest proportion of switchers leave during and after the first three semesters of their biology education, which coincides to particularly arduous coursework in the biology major, as described previously; 2) based upon registrar data, over two times as many switchers leave for non-STEM majors than leave for STEM discipline, indicating that, for a significant portion of students, their time in the biology major is turning them off to other sciences as well; and 3) based upon the interviews, most switchers become interested in and find a new major after they leave biology, often following a setback or the realization that they are no longer interested in biology or a career connected to it (Tables 4.57 through 4.61). As collected from qualitative and quantitative results, the major reasons switchers left the biology major

were: interest in and preference for other disciplines; changing plans; workload difficulties; personal encouragement; poor performance; and not belonging or fitting in.

Interest in and Preference for Other Disciplines

In terms of interest and preference, the quantitative and qualitative results did not align. The quantitative results show that 79% of switchers reported leaving the major because they preferred another discipline over biology. In addition, 69% of switchers reported leaving the major because they were more interested in their other courses than their biology courses (Table 4.57). These results are supported by Strenta and colleagues (1994), who found that 86% of male and 90% of female non-science switchers left biology due to interest in other disciplines. Similarly, Seymour and Hewitt (1997) found that 44% of switchers left out of preference or because other disciplines offered a better education or more interest; and that 37% left because of a lack or loss of interest. In this study, half of switchers interviewed described leaving because they were not interested in biology.

However, in interviews, the majority of switchers described choosing their new major after leaving biology (Table 4.60), sometimes several semesters afterwards. Moreover, among the almost one-third who mentioned being exposed to another discipline during college as a reason for leaving, not one left for that particular discipline. Instead, that discipline became the first in usually a series of stepping-stones to another major. In addition, the quarter of interview participants who reported leaving because they had other interests besides biology had those interests prior to enrolling in college. Therefore, there is little to no evidence that students in this study were being pulled to another discipline. Rather, they left biology for whatever reason and then began the search for a new major.

The difference between these qualitative and quantitative results could be due to sample size effects or it could be due to data contamination, whereby switchers are more likely to claim on a two-dimensional questionnaire that they left biology out of preference for another discipline because they currently prefer their new discipline. Considering the limited opportunities for outside coursework beyond the introductory level during their first two years of college and the general lack of research into other disciplines that both persisters and switchers engaged in during this time period, it is rather improbable that 79% of biology switchers just happened to take a course in another discipline that was so engaging they had no choice but to leave biology.

Further evidence that preference for other disciplines was not as salient a reason for switching as indicated on the questionnaire, is that a third of switchers interviewed were not particularly enthused about their new major. Although most appreciated the aspects of their new major they deemed failing in the biology major, I was struck by how uninspired some of the switchers were when telling me about their new major or why they chose it. Of the sixteen switchers I interviewed, six were happy about where they ended up after leaving the biology major, with a few even giving credit to their time in biology for helping them find a new path; four had only taken one or two courses in their new major and were still deciding if they enjoyed what they were doing; and the remaining six, however, seemed uncommitted to their new major, most often noting that it was a compromise that allowed them to graduate within four years or still get credit for their science coursework.

Changing Plans

On the questionnaire, 67% of switchers reportedly left the biology major because they changed their minds about what they wanted to do after college (Table 4.57). For the most part, as evident in interviews, this was synonymous with reevaluating the

viability of medical school admittance or attendance. Unlike Seymour and Hewitt's (1997) finding that 30% of switchers did so as a shift to a more-appealing non-STEM career, based upon interview participants' responses, very few reported they had another career in mind when they switched. Moreover, as indicated in participants' descriptions in interviews, this was not necessarily, as Seymour and Hewitt (1997) described, a rejection of STEM careers and associated lifestyles. While four of these nine switchers left biology because they specifically did not like the idea of teaching or research as a profession, five left to find a better backup in case medical school did not happen. In addition, six switchers left biology because they changed their minds about or decided they could not get into medical school and all but one left biology at the same time they decided against medical school. For these switchers, getting a biology degree was a means to medical school and once medical school was no longer an option; there was no reason to continue pursuing a biology degree.

Based upon the descriptions of interview participants, it was apparent, in general that both switchers and persisters had a poor understanding of what graduates do with biology degrees and very few of them had researched their options. For all of the switchers and half of the persisters, there were only three options: teaching, research/graduate school, and medical school. Although these encompass three major areas connected to biology, they are certainly not representative of the many options available to biology graduates (Eyster, 2007).

Workload Difficulties

As reported by three-quarters of interview participants, the most reported reason for leaving biology was due to difficulties with the workload (Table 4.60). However, these types of responses were not salient reasons for switching among questionnaire participants, with less than 30% leaving due to workload difficulties. This reason for this

discrepancy is unknown, but could be caused by my purposeful selection of interview participants (5 out of 16) who represented the lower half of the performance curve.

Previous studies by Seymour and Hewitt (1997) and Strenta and colleagues (1994) demonstrate that workload difficulties were among minor reasons for switching. Seymour and Hewitt found that less than one-quarter of their switchers left STEM majors due to workload and/or pace of their courses; Strenta and colleagues found that just over two-fifths of switchers left STEM majors because the work was too difficult. The results of this study do not coincide with the above studies for two likely reasons: 1) both Strenta and colleagues (1994) and Seymour and Hewitt (1997) sampled from "high-ability" students; and 2) both studies included all STEM majors, not just biology. This latter difference is important because the incongruence may be due to students' initial and incorrect perception that biology is easier than the other sciences (recall that over half each of persisters and switchers reported choosing biology because it was easy for them). Therefore, it is possible that students may perceive the workload in college biology as extreme simply because they expect it to be easy. Similarly, it is possible that because students expect the workload in other STEM disciplines, particularly unfamiliar ones, to be high, difficulties associated with workload have less of an impact on their decision to leave those majors.

Adding to this and consistent with findings from Seymour and Hewitt (1997) is that switchers and particularly persisters tended to characterize the work required in other disciplines as easier or lighter than the work required in biology. This type of discrepancy has the potential to exacerbate students' difficulties with workload because it implies that biology is empirically hard, rather than differently hard. Interestingly, research concerning course-taking among science majors shows that students' perception of biology having a higher workload is not unfounded. Micceri's (2005) analysis of the

course-taking behaviors of 39,087 graduates from Florida State University System institutions revealed that biology students take more science courses than all other students and more math and physics courses, excluding students majoring in those disciplines.

Personal Encouragement

Half of switchers interviewed, but considerably fewer questionnaire participants, described deciding to leave, in part, because someone encouraged them to switch their major (Table 4.60). Whether this encouragement came from parents, friends, or advisors, all of these switchers reported feeling validated by this encouragement. Moreover, without exception switchers' family and friends were very supportive of their decision to leave the major. Despite this, only one switcher described someone encouraging her to stay in the major.

> I had one TA whenever I was like, "Yeah, I'm switching to advertising. It just makes better sense for me," and she was like disappointed, like I could tell she was disappointed and she said, "You're smart, like we need smart women in science."…and I was like, "Oh, I'm gonna die," you know?...She was the only person that made me think twice about it…but had I had maybe like a handful more people like her telling me that I was smart enough to do it and that maybe I should reconsider, that I was one of their good students or that they valued me in some way, like, I might've, you know, been like, "Well, lemme think about this a little longer."

Combined with the findings that only one-third of persisters interviewed described an instance of someone encouraging them to stay in the major and that almost all of this encouragement came from peers demonstrates two related problems: 1) how little biology students communicate their misgivings to other biology personnel, including faculty; and 2) intentional or not, how oblivious biology personnel are to students' switching decisions.

Performance

As seen in questionnaire results, 67% of switchers reported they left the biology major because they found they had a higher aptitude for another discipline and 57% reported that they left because they performed better in other courses than they did in biology courses. Although almost half of interview participants reported that they left biology because of poor performance in courses required for the major, only 32% of questionnaire participants left biology because of poor performance in their biology courses (Tables 4.57 and 4.60). This lower result indicates that although performance was a factor, it was primarily comparative performance that contributed to leaving decisions. In addition, quantitative comparisons of switchers' and persisters' opinions of various aspects of the biology major showed large effect size differences concerning their opinions of their learning and performance outcomes, including their understanding of biology, their grades, and the degree to which their grades reflected their understanding (Table 4.24)

In life story interviews, comparisons of lower-performing and higher-performing switchers showed that performance had a tremendous effect on the former's and very little to no effect on the latter's decisions to leave. This may explain why less than one-quarter of Seymour and Hewitt's (1997) informants left due to performance and the majority left out of interest: it is less likely that student would report performance as a reason for leaving, and more likely that they would make a decision based upon interest if they perform well in all of their courses or amongst their peers (described further in "Finding Eight"). Furthermore, when I asked lower-performing persisters why they left the major, only one described their performance as a reason; however, when I asked how their performance affected their decision to leave, they all described performance as being the main consideration. This provides some insight as to why previous studies into

switching have had inconclusive evidence of the role of performance (i.e. Seymour & Hewitt, 1997). Since all of the interviewees and focus group participants who mentioned poor performance blamed themselves for their grades, it is likely that, unless directly asked about performance, students will conceal these perceptions out of embarrassment.

Not Belonging or Fitting in

Based upon questionnaire results, 67% of switchers reported they left because their talents were best suited to other disciplines (Table 4.57), which is supported by Manis and colleagues, (1989) finding that 60% of male and 71% of female non-science switchers left because "other fields made better use of my talents." In addition, over half of questionnaire participants reportedly left biology because they felt it was wrong for them; likewise half of interview participants reportedly left biology because they did not belong or did not fit in (Table 4.60). Based upon interview descriptions, it appears that the major reason for this lack of belonging was due to switchers' perceptions of other students' capabilities or behavior. Switchers explained they felt they did not belong because of a mismatch between theirs and others' abilities, goals, or social and/or intellectual position. In terms of the first two types of "not belonging" responses (abilities or goals mismatch), Seymour and Hewitt (1997) explained it best with their claim that "the fortitude shown by survivors reinforces the self-doubts of those who leave. (p. 105)." In this study, these switchers believed they did not belong because others were performing better, understood more, or were more serious about their future plans. Neither of these types of "not belonging" responses indicated where switchers felt they did belong, just that they did not belong in the biology major. On the contrary, the last type of "not belonging" response (social or intellectual mismatch), most often expressed as being superior to biology majors in some way, was less about not belonging in biology, and more about belonging elsewhere.

Finding Eight: The Role of Performance in Staying and Leaving

As demonstrated in interviews, it was not performance alone that affected persistence, but performance in comparison to other students' and that of other courses that affected their decision to continue in or leave the biology major. Relevant scenarios demonstrating this are detailed below.

If a student was earning high grades in all of their courses, their performance was no longer a viable part of the decision process, as demonstrated in descriptions of higher-performing switchers and persisters. Instead, as Seymour and Hewitt (1997) found, interest and enjoyment became the gauge with which they made decisions about the appropriateness of their course of study. Despite implications to the contrary, participants who considered themselves as high-performers in biology did compare their grades to those of their peers. Their performance in relation to peers or the curve was precisely how they knew they were high-performers.

If a student was earning higher grades in biology than in other courses (especially other science courses), this confirmed their choice of biology as a major, as demonstrated in descriptions of several persisters. This confirmatory effect was also popular among the persisters who reported staying in the major because they did not want to give up or give in or because they never considered leaving. Contributing to this confirmatory effect was that many of these persisters found no realistic alternatives to the biology major when they had second thoughts about continuing. As demonstrated in the previous scenario, interest and enjoyment became the measure for persistence.

If a student was earning lower grades in biology than their peers or in other courses, then their persistence largely depended on how they viewed their peers and these other courses, as evident in the descriptions of several interview participants. In terms of their perceptions of their biology peers, lower-performing persisters tended to view their

peers as models for behavior; whereas lower-performing switchers tended to view their peers as more capable or cliquish. Among these switchers, comparatively poorer performance in biology was evidence that they should leave the biology major. In terms of their perceptions of their non-biology courses, lower-performing persisters tended to view these other courses as less interesting than biology; whereas lower-performing switchers tended to view these other courses as more interesting than biology. Though both groups regarded their biology coursework as difficult, the persisters were more likely to characterize the work as worthwhile for learning or for their future plans; and the switchers were more likely to characterize the work as unnecessarily difficult and time-consuming. As shown in the results, these ideas often reflected their perceptions of the faculty teaching these courses as well. The source of the divergence between lower-performing persisters' and switchers' perceptions of what their grades meant is unknown, but nonetheless contributed to their decisions.

The implications of these trends are that persistence in the biological sciences can be enhanced by 1) creating classroom environments that simultaneously invite collaboration and squelch competitive behaviors; and 2) developing biology courses, particularly at the introductory level, that are both interesting and worthwhile.

Summary

The results of this study indicate that very little separated biology freshmen in terms of their interest in biology, including their precollege experiences, sources of encouragement, and reasons for choosing the major. While there is still a possibility that having naïve or inappropriate reasons for choosing biology predisposes departure, that both switchers and persisters made uninformed choices regarding their major makes this questionable. Where future persisters and switchers differed was in their experiences during their first two years of their education and their interactions with and perceptions

of the people connected to the biology major. Because both persisters and switchers had had poor experiences in the major, it appears that what initiates eventual departure from the biology major is that these poor experiences are not subsequently erased by better ones. Unfortunately, this could mean that chance plays a role in determining persistence or departure. Pleasant or unpleasant accidents in the form of which professors teach their courses, what advice they receive, what combination of courses they take during their first two years, and which peers end up in their courses or cohort groups, appear to have an additive effect for biology students. For persisters, the totality of these experiences confirmed their interest in biology as well as their goals following graduation, and led them to "not leave" the major. For switchers, the totality of these experiences eroded what interest they had and led them away from the major. Regardless of the reason they left, the roots of their departure lay in how they experienced biology, and not in their decisions prior to matriculation.

While I would like to contend that only difference between switchers and persisters is that switchers tend to have poor college biology experiences and persisters tend to have good ones, the fact that some of the persisters also had poor experiences in their courses, with faculty, and with peers makes this assessment at least partially untrue. Though I did not set out to find the answer to this question, I find myself compelled to try to answer the following: "All things being equal, what makes a switcher a switcher and a persister a persister?" The answer, nonetheless obvious, seems to be: if a student likes biology or what it will lead to enough to compensate for the difficulties s/he will experience in the major, then s/he is likely to persist. Thus, it seems that an apparent difference between biology persisters and switchers is that the persisters were willing to tolerate difficulties associated with the major and switchers were not. This has an ugly implication, namely that persistence really means wanting it badly enough. As evident in

a few persisters' refusal to leave the major, this is, at least partly true. However, I do not believe that simply "wanting it badly enough" that promotes persistence; rather it is wanting it badly enough to make the behavioral changes necessary for persistence.

Therefore, based upon the findings of this study, I have found that a remarkable difference between biology persisters and switchers was that, whether by calculated effort or by sheer desperation, persisters created for themselves a network of support, and switchers, for the most part, did not. The network persisters created included faculty, peers, and experiences that helped make their biology education more worthwhile and relevant to them. Creation of this network required a lot of effort on the part of persisters and less often involved assistance from biology personnel, as one persister expounded a common phrase repeated by persisters, "having to do it yourself:"

> …You have to do everything yourself…like you have to put out the effort to go see your professor, and to find out what's out there, like to find out what kind of major you want. You have to actually go and figure it out. They don't have it for you. And…I had to learn how to make new friends 'cause…I was the only one [of my high school friends] that came here…and the only way to meet new people was to form a study group and I had to actually like get out of my shell and like approach other people to do that, and that was a big learning experience 'cause I'm pretty shy, or I was before.

The implications for institutions are two-fold: if we want students to persist in STEM majors, including biology, we need to create experiences that promote persistence and train students how to persist. This means: 1) providing and requiring them to use the tools and the resources they will need to make reasonable and well-informed decisions; and 2) providing experiences that will help make their efforts relevant and worthwhile.

COMPARISON TO THE STUDENT-CENTERED THEORY OF PERSISTENCE

As explained in Chapter One, this study utilized Stage and Hossler's (2000) Student-Centered Theory of Persistence. I chose this model because it is predicated on the idea that students, as adults, are active participants in their education, and the

decisions they make therein. This next section includes a discussion of each of the interacting elements of their model that contribute to persistence and departure, as well as data from this study appropriate to each element. These elements were Background and Family Involvement; Precollege Academic Experiences; Intentions, Engagements and Preparation with Regard to College; and College Entry and Social and Academic Involvement.

Background and Family Involvement

The background measures included in this study were encouragement from family and parents' education level. Encouragement from family fits under Bandura's (1977, 1995, 1997) construct of social persuasion, one of the sources of self-efficacy. As mentioned in the first section, encouragement from parents was important in not only developing students' interest in biology, but also, in their choice of the biology major. Parents' education level fits under Bandura's (ibid.) construct of vicarious experience, a more authentic source of self-efficacy than the aforementioned social persuasion. Recall that survival analysis showed no difference between first generation and traditional college students in terms of persistence in the biology major.

Pre-college Academic Experiences

The precollege measures included in this study were student ability and high school experiences and personnel. In their model, Stage and Hossler (2000) placed student ability within the context of encouragement because of the cyclical relationship between a students' performance and the encouragement they receive from parents. However, since their model presumes that all of the blocks are related, and relevant student abilities are part of the school experience, particularly high school, I have moved these into this block of the model. Student ability, particularly in high school, would

count as mastery experience, or the most authentic source of self-efficacy. The importance of this is evident in the fact that a major reason both switchers and persisters chose the biology major, in part, because they did well in high school biology. In addition, the only precollege source of encouragement participants rated as more encouraging than their parents were their high school biology teachers and both were important in their choice of major. That there was little effect attributed to high school peers and counselors highlights one way in which Stage and Hossler's model is less appropriate for major persistence and more appropriate for institutional persistence.

Intentions, Engagements and Preparation with Regard to College

The intention and engagement measures included in this study were advice-seeking, volunteering, and taking college preparatory coursework, each of which Stage and Hossler (2000) regard as "getting ready" behaviors that are positively associated with persistence.

Considering the primacy of high school experiences in these decisions, the number of participants who chose biology out of ignorance, and the number of participants who regretted the amount of research they did prior to coming to college, there is little evidence that advice-seeking or information-gathering is positively associated with persistence in the major. In fact, outside of what information they collected by watching television, the bulk of participants' information-gathering activities took place following matriculation, particularly after an academic setback occurred. Based upon participants' poor assessment of their own research abilities, the variability of resources available to entering freshmen, as well as vagaries of the advising structure, this is an area for institutional improvements.

In terms of volunteering, "working with patients," which, based upon interviews, came in the form of volunteering in hospitals and long-term care of family members, was

important in developing students' interest in biology and formed another mastery experience informing students' career choice. That 76% of persisters and 68% of switchers reported working with patients as moderately to extremely important in developing their interest in biology (Tables 4.1 and 4.2), is demonstrative of the intimate link between biology and medicine, particularly at the high school level. As evident in interviews, these volunteer experiences did not necessarily amplify students' interest in the medical field, since some of the participants decided against medical school (but not biology) because of poor volunteer experiences.

In terms of taking college preparatory courses, there was no association between taking additional biology in high school and persistence in the major. While potentially an effect of sample size, there was no difference in persistence among students who took less than one year (n=44), one year (n=211), or two or more years (n=62) of biology (x^2=1.071, df=2, p=0.585). This contradicts Astin and Astin's (1993) finding that, in addition to having high SATM scores and earning good grades in biology, taking multiple biology courses in high school was a significant predictor of final choice of the biology major (i.e. persisting).

Although there is some evidence that "getting ready" behaviors should be associated with persistence in the biology major, it is clear from the above results that they are not. I do not think this means that Stage and Hossler's (2000) model should be revised in any way. Rather, this highlights a way in which the model may not be appropriate for considerations of major choice, particularly for institutions that do not funnel students into a major upon matriculation.

College Entry and Social and Academic Involvement

The college behavior and experience measures included in this study were goal-setting, academic involvement, and social involvement. In this study, academic

involvement consisted of course experiences, and formal relationships with biology faculty, advisors, and peers, and social involvement involved informal relationships with biology peers.

Goal-Setting Behavior and Goal-Orientation

There were three indications of goal-setting behavior that can be gleaned from results. First, being a BS degree-seeker was a predictor of survival in the major. This was amplified by the greater survival of BS-health professions degree-seekers over all other types of degree-seekers, indicating that not only academic goal-orientation, but professional goal-orientation was positively associated with persistence.

Second, within the population of biology freshmen, there was a statistically significant redefinition of their goals following matriculation. As mentioned in "Finding Six ," 51.4% of the students who started out and graduated with a biology degree switched their major at least one time while they were enrolled, and another 13.4% switched it more than one time while they were in college. Moreover, there was a significant shift from the BS to the BA degree, further indicating that these goal refinements may be necessary for some portion of students to persist.

Third, while it is appropriate for students to change or modify their goals due to new interests or new understanding of themselves or aspirations, these were not necessarily the primary stimuli instigating these changes. More often than not, as evident in interviews, changes to other majors were typically in response to poor grades and difficulties with coursework, indicating that, for many, the initial stimulus for departure is a negative rather than a positive one. Supporting this finding is that 11 of the 14 most commonly agreed-upon questionnaire items about leaving were negative in connation.

Academic and Social Involvement

Academic and social involvement, typically referred to as integration (see Tinto, 1993), has been defined in a multitude of ways, depending on the focus of the retention study. In general, the difference between the two is formality, whereby academic involvement includes formal relationships with faculty, advisors, peers and the institution itself and the latter includes less formal relationships with the same (Stage & Hossler, 2000; Tinto, 1993). What will be discussed in the following section are namely their course experiences, including performance, and their experiences with faculty, advisors, and other students.

First, students' course experiences, like those in high school, were mastery experiences that provided participants' evidence informing their decisions (Bandura, 1977; 1995; 1997). Both switcher and persister ratings of different aspects of their biology courses and their descriptions of their course experiences demonstrate that course experiences had a large effect on persistence, particularly in the case of first year science biology experiences, as noted previously. Moreover, survival analysis demonstrating that most students leave during those first two years and significantly more students leave for non-STEM than other STEM majors indicates that experiences during the first two years are alienating a significant portion of students from the sciences. Lastly, as evident in questionnaire data, that 67% of persisters reportedly stayed in the biology major, in part, due to their performance in biology and 57% percent of switchers reportedly left the biology major, in part, because they performed better in their non-biology courses, demonstrates that performance, particularly in comparison to other courses was associated with their persistence decision.

Second, positive contact with biology advisors, faculty and peers, was associated with persistence in the major. Overall, as mentioned previously, persisters had

better experiences with these individuals than did switchers. Advisors had the smallest impact on participants' persistence in or departure in the major, by offering lower level social persuasion for or dissuasion from the major. Relationships with faculty had a stronger impact on participants' persistence, with these relationships offering mastery experiences (lab and field work) and some social persuasion (contact with faculty outside of class). Lastly, peers seemed to have the strongest impact on persistence, with these relationships providing mastery and vicarious experiences (partnerships) and social persuasion (friendships and comradeships). Together, these findings imply that persistence in the biology major may require the blending of the academic and social realms of college, with formal and informal relationships with faculty and peers.

In response to one of Stage and Hossler's (2000) potential research questions, this study provides some evidence, in the form of cohort groups, that student-initiated involvement is much more of a predictor of persistence than institution-initiated involvement. While, cohort groups seem to work in terms of helping students make friends (purely social involvement), they did not seem to help students academically, particularly for students who were not doing as well as other members of the cohort group. For these switchers, cohort group participation appeared to have either caused or exacerbated feelings of not fitting in or belonging in the major. Furthermore, these switchers less often mentioned studying with the other members of their cohort group, which implies that the reality of cohort group participation was opposite of its intention.

Appropriateness and Refinement of the Model

Despite some areas in which there is limited involvement in terms of persistence (i.e. "getting ready"), overall the model is appropriate for major choice and persistence/departure, particularly if the effects of earlier elements in the model become diluted over time. However, I do have one suggestion for refining the model for future

testing: transform the college entry and social and academic involvement element into two elements or designate the college entry portion as the arrow. For Stage and Hossler (2000), these potentially different time periods may be fused into a single element because so many students leave college during the entry period. However, because so much of what determines student persistence or drop-out happens during the time students are in college and since the transition from high school to college is similar to passing through a membrane into another world, adding an element or changing the arrow would both account for these potentially different time periods and demonstrate the other-worldliness of college life.

RECOMMENDATIONS

Creation of a Career-Planning Course

Regardless of whether they ultimately stayed or left the major, it is apparent that participants in this study chose their major based upon limited informational resources. While primary experiences are the most authentic evidence with which to make decisions, high school experiences are neither varied nor challenging enough to use when selecting a major. As evidenced in this study, most of the participants had no idea that other majors were, either in terms of the disciplines themselves or the careers stemming from them. Although most of these participants took ownership of their lack of research prior to and during their first semester of college, this lack of knowledge is a problem to be remedied at the institutional level.

As I previously recommended in my thesis (Lang, 2004), a way to teach first year students about different disciplines is to create a required one-hour freshman-level seminar designed to disseminate not only accurate information about the different majors on campus, but the career options connected to those majors. Ideally in a symposium

format, each class period would be led by panels of representatives of one or more disciplines, namely professors, those working in-field, and recent graduates. In addition, the course should include career assessments to help students understand their interests so that they can make informed decisions that are not primarily based upon their high school experiences. Providing adequate information to our students about their options is in our best interests because it has the potential to prevent not only the front-loading of students into the disciplines to which they were exposed during high school, but also the concomitant losses of students from those disciplines during the college years.

Effective Management of Health Professions Students

Because the first two years of the biology program, at least at The University, are associated with the greatest risk of departure and coincide with the majority of biology students' complaints about the behavior of their premedical cohorts, I suggest separating health professions and non-health professions students in the long semester versions of BIO 311C (Introductory Biology I), BIO 311D (Introductory Biology II) and, ideally, BIO 325 (Genetics). Though a potentially extreme measure, this and other studies give ample evidence that the competitive behavior within science courses is largely due to health professions students and that the effects of this competition feed into the departure problem (Manis, et.al., 1989; Seymour & Hewitt, 1997; Strenta, et.al., 1994). The important question we as biology educators must ask ourselves and our departments is: if approximately half of our biology students are going to leave the biology major, who do we want to retain? More specifically: are we in the business of devoting resources to retain those who have no intention of working, teaching, or pursuing graduate education in the biological sciences, or are we in the business of devoting the resources necessary to retain those who do? Though removing premeds from biology classrooms is not going to eliminate competition among students, it will likely lessen it to a degree that it improves

classroom climate, and reciprocally improves the biology education of both premeds and non-premeds alike. Instructors would inevitably teach their courses differently if they knew their entire student population consisted of students more interested in future employment the health professions, versus one that contained students more interested in learning about biology for other reasons. Furthermore, with this kind of change, biology courses would become a haven from the competition that will still plague the other courses required for premedical education, namely calculus, introductory chemistry, organic chemistry, and physics.

In addition to separating these students during these pivotal semesters, I suggest the creation of a premed minor. This would ultimately lower the number of students majoring in biology and subsequently improve the advising available to biology majors. If students were actually given credit on their degree for taking their premedical requirements, they would be less intent on pursuing a biology degree, or other science degree, to prove that they are worthy of medical school. Since the premedical requirements are standard at this and other universities, the addition of a minor would be relatively easy. Moreover, the creation of a minor would ensure adherence to premedical requirements and thus consistency among graduates interested in a medical career. While this is not necessarily a huge problem, I found evidence during interviews that some "premed" students do not classify themselves as such because they either do not officially add the premed advising code to their degree plan or, more problematically, do not want to fulfill the recommended premed requirements above those required for the MCAT.

Reversal of Introductory College Biology Curriculum

Since introductory courses are turning students off to biology, and worse, to other STEM majors as well, then reconfiguration of introductory education should be a priority. Based upon the complaints of switchers, including those who did well in their

courses, introductory biology is, in short, a mountain of details meant to be memorized in a short period of time. Despite the fact that this assessment is indicative of a utilitarian and novice understanding of the structure of biology, if a significant portion of biology students view the discipline this way, then introductory biology is not being taught in a way that promotes student advancement to higher levels of biological literacy (Uno & Bybee, 1994). Therefore, my recommendation is to teach sciences, including biology, the way all other disciplines are taught at the college level, thematically from the big to the small, rather than the reverse.

Our own educational biases and our over-reliance on textbooks to provide our curriculum has trained many of us to teach students the details before teaching them the big picture, which is not only counterintuitive and against much of what we know about how people learn, it is incredibly boring for both teachers and their students. There is no logical reason why students have to first learn about the parts to understand the whole, other than the fact that textbooks are arranged from atom to ecosystem. Instead of blindly following unnecessarily encyclopedic biology textbooks, we should teach biology from ecosystem on down, following each theme to its molecular origin. Teaching introductory biology this way will: 1) enhance students' understanding of the connections between the organizational levels and complexity of biology; 2) train students to zoom in and zoom out, a skill absolutely critical for a multidimensional understanding of biological concepts and processes; and 3) help students create a framework into which they can transfer new biological concepts. Most importantly, teaching backwards mimics the best of how people actually learn: by asking big questions and allowing students' own curiosity to draw them into the details.

Creation of a Campus Initiative to Stop Student Discussion of Grades

Before explaining this recommendation, I will reveal my bias as a graduate of Bryn Mawr College, one who pledged as part of our Honor Code not to discuss grades with my peers and grew to appreciate my academic life being more about improvement and mastery than performance and grade-grubbing. Excepting this, I could not help but wonder if some portion of my interview participants would have had better experiences in the major if they had not been pressured to become part of the competitive culture by being asked about or by actively discussing their grades with other students. Therefore, I recommend creating an initiative that discourages students from discussing their grades. The logical place to begin this culture is with the freshman class, namely within the ever-expanding cohort programs on campus. Since the effects of grade disclosure seemed the most hurtful to students in cohort groups, this is where changes should begin.

Here are the three reasons why discussion of grades should cease at The University. First, it is rude, immature behavior that has no place in an environment entirely populated by adults. Secondly, allowing students to use grades as a comparative tool reinforces the idea that students are their grades. If we really want to control the grade-grubbing and consumerist attitude of students, then we need to shift their focus from defining themselves by their grades. The first step of doing that is removing other students' grades from the equation. The next step will be helping students understand through our teaching and assessments, that learning is about mastery, not performance. Thirdly, and most importantly, it's unprofessional. If we are in the business of preparing these students for the workforce, then we should demand that they behave as they are expected to in the workforce. Since employees are not allowed to discuss salaries or employment evaluations with fellow employees, students should not be allowed to discuss their grades with peers.

AREAS FOR FUTURE RESEARCH

Because what is true at The University is not necessarily true for other institutions, a likely starting point to further investigate entrance into and attrition from the biology major is to expand the study to a wider sample of colleges and universities. Ideally these studies would be longitudinal in nature, following cohorts of students from matriculation, and would involve repeated data collection to minimize the effect of data contamination from present circumstances. Second, because what is true for biology is certainly not true for other STEM disciplines, it is appropriate to investigate departure from other individual STEM majors as well. Third, because this study provides some evidence that one difference between switchers and persisters is their resource use during college, a worthwhile extension would be to analyze which and to what degree students utilize the resources connected to the biology major (i.e. instructors, research opportunities, study groups, organizations, etc.) and the institution (i.e. career counseling, academic assistance such as tutoring, cohort programs, etc.). Fourth, because there seem to be apparent differences between the perceptions of grades among lower-performing students, it would be worthwhile to expand the investigation to a larger sample and find out what students define as good grades and how they weigh their grades when making decisions about major choice and persistence. Fifth, because the complete story of STEM persistence must include finding out how students become attracted to STEM majors, it would be appropriate to investigate the choices of students who switch-in. Lastly, based upon repeated evidence that non-Asian minorities have the lowest rate of survival in STEM majors, and due to results of this study, it appears that the problem is not underrepresentation, but retention, it would also be appropriate to investigate persistence and departure among non-Asian minorities in individual STEM majors.

Appendices

APPENDIX A: QUESTIONNAIRE

You have been invited to take this survey because you were classified as a biology major during the first semester you were enrolled at UT. The purpose of my study is to investigate why some biology undergraduates choose to leave the biology major and why some biology undergraduates choose to stay. You will be asked questions about your experiences before college, as well as your experiences during college. Please note, your answers will be confidential and your participation will not at all affect your relationship with the University. The survey will take approximately 20 to 30 minutes to complete. At the end of the survey, you will be asked if you would like to participate in interviews and/or focus groups. If you are interested, please enter your email. Note that if you are chosen for additional research, you will be paid for your time.

Please click the link below if you wish to take the survey. Otherwise, please close your browser.

I appreciate both your consideration and your time immensely. If you have any questions about the survey, please email me at slang13@mail.utexas.edu

Demographics

From this point forward, it should take you approximately 20 to 30 minutes to complete this questionnaire. Your responses are anonymous and will be kept confidential. This questionnaire has skip-logic, so you will skip the portions of the questionnaire that are irrelevant based upon select answers. Please note that if you exit the questionnaire prematurely, you will be brought back to the point you left off when you log in again, provided that no one else has accessed the survey from the computer you are currently using.

1. Gender:
   - □ Female
   - □ Male
2. Ethnicity (choose all that apply):
   - □ African/African-American/Black
   - □ Asian-American/East Asian/South Asian/Southeast Asian
   - □ Chicano/Latino/Mexican-American
   - □ Middle Eastern/West Asian/North African
   - □ Native Alaskan/Native American/Native Pacific Islander
   - □ White/European
   - □ Prefer Not to Answer
   - □ Other (please specify)
3. Age: _____

4. Will you be the first person in your immediate family to graduate from college?
   - Yes
   - No
5. Was the College of Natural Sciences your first choice when you applied to UT?
   - Yes
   - No
6. What is your current status?
   - Freshman
   - Sophomore
   - Junior
   - Senior
   - Graduate Student
   - Non-Degree Seeker
7. What was the first year you were enrolled at UT?
   - 2001
   - 2002
   - 2003
   - 2004
   - 2005

   In what year do you expect to graduate from UT?
   - 2006
   - 2007
   - 2008
   - 2009
   - 2010
   - 2011
   - I already have a degree.
8. How many semesters of biology did you take in high school?
   - 0
   - 1
   - 2
   - 3
   - 4
   - 5 or more
9. Current GPA. _____

   To check your current GPA, click on the following link: (link removed)
10. Biology Grades. If you took a course more than one time, enter the highest grade you received for that course. If you received AP credit or Credit By examination, please choose CR for credit. To look at your grades online, click on the following link:

    Grade Choices: A B C D F CR Q/W Did not take
    - BIO 302C (Advanced Introduction to Genetics)
    - BIO 205L (Cell and Molecular Biology)

- BIO 206L (Structure and Function of Organisms)
- BIO 208L (Field Biology)
- BIO 211 (Cell Biology)
- BIO 311C (Introductory Biology I)
- BIO 311D (Introductory Biology II)
- BIO 212 (Genetics and Evolution)
- BIO 213 (Diversity and Ecology)
- BIO 214 (Structure and Function of Organisms)
- BIO 325 (Genetics)

11. When you first enrolled in college, what was your advising area?
    - Premedical
    - Predental
    - Preveterinary
    - Prepharmacy
    - Allied Health Professions
    - UTeach
    - I did not have an advising area
    - Other (please specify)
12. What is your current advising area? If you already have a Bachelor's degree, what was your advising area when you graduated?
    - Premedical
    - Predental
    - Preveterinary
    - Prepharmacy
    - Allied Health Professions
    - UTeach
    - None
    - Other (please specify)
13. When you first enrolled in college, what was your major?
    - Undeclared Natural Sciences
    - BA Biology
    - BS Biology: Ecology, Evolution and Behavior
    - BS Biology: Human Biology
    - BS Biology: Marine and Freshwater Biology
    - BS Biology: Microbiology
    - BS Biology: Cell and Molecular Biology
    - BS Biology: Neurobiology
    - BS Biology: Plant Biology
    - BS Biology: Teaching
    - BS Clinical Laboratory Science
    - Other (please specify)

14. For approximately how many long semesters were you or have you been a biology major? Please do not include summers in your calculation.
    - 1
    - 2
    - 3
    - 4
    - 5
    - 6
    - 7
    - 8
    - More than 8

Interests and Influences

Regardless of whether or not you are currently a biology major, you were at one time interested enough to choose it as a major. The following questions are meant to assess the different influences upon that interest, as well as reasons for majoring in biology.

15. Please rate the following items on how important they were in developing your interest in the biological sciences BEFORE you entered college. If you did not experience something, choose N/A. If you had pre-college experiences besides the one listed below that helped develop your interest in biology, please describe and rate them in the next question.

    Rating Scale:
    1 = Not at all important
    2 = Slightly important
    3 = Moderately important
    4 = Very important
    5 = Extremely important
    0 = N/A

    Items:
    Participating in science fairs in elementary, middle, or high school
    Having a family member or mentor who majored in the biological sciences
    Visiting science museums
    Reading journal articles or non-fiction books about biology, medicine or science
    Participating in scientific research during high school or between high school and college
    Working with animals (e.g. caring for pets, FFA, working at a ranch, vet clinic, shelter, etc.)
    Having a family member or mentor who worked in the biological sciences
    Having a family member or mentor who worked in the health professions (medicine, dentistry, veterinary, nursing, etc.)
    Watching educational TV programs about biology, medicine or science (e.g. Discovery Channel, PBS, National Geographic Channel, etc.)
    Performing well in middle school life science course(s)

Field or laboratory experience in middle or high school life science course(s)
Performing well in high school biology course(s)
Visiting zoos, botanical gardens, marine parks, or safari parks
Participating in summer programs or internships in the life sciences
Having direct experiences with nature when camping, fishing, going to the beach, etc.
Working with patients (e.g. caring for sick family members, working or volunteering in a nursing home or hospital, etc.)
Reading science fiction books about biology, medicine or science
Attending the rodeo, livestock shows, or the circus
Watching prime-time TV shows or movies involving biology, medicine or science (e.g. ER, CSI, etc.)
Having a family member or mentor who taught biology
Having a friend or family member with a protracted illness (e.g. cancer, heart disease, diabetes, etc.)
Enjoying high school biology course(s)
Having a protracted illness (e.g. cancer, heart disease, diabetes)
Being a patient in the hospital or being treated by a physician or dentist
Enjoying middle school life science course(s)
Working with plants (e.g. caring for houseplants, gardening, agriculture, FFA, etc.)

16. Other precollege experiences that developed your interest in biology, not listed above.

_____

17. Please rate how each of the following persons either encouraged or discouraged your interest in the biological sciences. If you have had experiences with more than one person of each type, for example more than one high school biology teacher, rate their average effect on your interest in the biological sciences. If you did not have experience with a particular person (for example, if you do not have siblings), then choose N/A. If you were encouraged or discouraged by other persons not listed below, please describe and rate them in the next question.

Rating Scale:
-3 = Greatly discouraged my interest
-2 = Moderately discouraged my interest
-1 = Slightly discouraged my interest
+0 = Neutral
+1 = Slightly encouraged my interest
+2 = Moderately encouraged my interest
+3 = Greatly encouraged my interest
X = N/A

Items:
Elementary or middle school counselor(s) or principal(s)
College biology instructor(s)
Friends from my childhood years (prior to high school)
Other adult family members (grandparents, aunts, uncles, etc)
Friend(s) from college
College biology advisor(s)
High school biology teacher(s)

Friends from my high school years
High school counselor(s) or principal(s)
Sibling(s)
Elementary school teacher(s) or science teacher(s) (grades K – 5)
Middle school science teacher(s) (grades 6 – 8)
Father or other male guardian
Mother or other female guardian
College biology TA(s)

18. Other persons who encouraged or discouraged your interest in the biological science, not listed above: _____
19. Students typically have multiple reasons for choosing a particular major. Think back to when you decided to major in biology and please rate the following statements based upon how well they describe your reasons for choosing this major. Note that you are rating how well they describe your decision to major in biology, not how they describe your current feelings about biology. If you have other reasons besides the ones listed below, please describe and rate them in the next question

Rating Scale:
1 = Not at all true of me
2 = Slightly true of me
3 = Moderately true of me
4 = Very true of me
5 = Completely true of me

Items:
I majored in biology because I thought biology was fun
I majored in biology because I wanted to work with animals (e.g., zookeeper, breeder, wildlife or fisheries manager, park ranger, etc.)
I majored in biology because my parent or another significant adult wanted me to work in a health profession
I majored in biology because I thought I had to choose a major in order to be admitted to the University.
I majored in biology because I was interested in genetics or genetic engineering
I majored in biology as a backup in case I did not get into medical, veterinary, pharmacy, or other professional school
I majored in biology because biology was easy for me
I majored in biology because I needed biology for my preprofessional educational requirements (e.g., premedical, prepharmacy, predental, etc.)
I majored in biology as a backup in case I changed my mind about medical, veterinary, pharmacy, or other professional school
I majored in biology because I liked animals
I majored in biology because I wanted to help people
I majored in biology because I was interested in anatomy and physiology
I majored in biology because my parent or another significant adult encouraged me or wanted me to major in biology
I majored in biology because I thought that biology was the most interesting of the sciences

I majored in biology because I was interested in botany or plant biology
I majored in biology because biology involved less or easier mathematics than the other sciences
I majored in biology because I was not interested in any discipline besides biology
I majored in biology because I was interested in learning more about biology
I majored in biology because it seemed like the best choice based on the options available to me
I majored in biology because I was interested in evolutionary biology
I majored in biology because I wanted to work with plants (e.g., horticulturalist, farming, landscaping, etc.)
I majored in biology because I knew that I could do well in upper division biology courses
I majored in biology because I thought that biology would best prepare me for my chosen career
I majored in biology because I wanted to work in a health profession (medicine, veterinary medicine, pharmacy, etc.)
I majored in biology because I wanted to do conservation work
I majored in biology because I was interested in microbiology
I majored in biology because I did not know what else to major in
I majored in biology because I wanted to do biological research or go to graduate school in biology
I majored in biology because I was interested in zoology, animal biology, or animal behavior
I majored in biology because I did well in high school biology
I majored in biology because I was interested in conservation biology or ecology
I majored in biology because I thought biology was the best degree to have for medical, veterinary or another professional school
I majored in biology because I was interested in cell, molecular, or developmental biology
I majored in biology because I liked biology
I majored in biology because I was interested in marine or freshwater biology
I majored in biology because I wanted to teach biology
I majored in biology to please my parents
I majored in biology because my parent or another significant adult majored in biology

20. Other reasons for majoring in biology, not listed above: _____
21. What is your current major? If you already have a Bachelor's degree, please choose the major in which you have a degree.
    - BA Biology
    - BS Biology: Ecology, Evolution and Behavior
    - BS Biology: Human Biology
    - BS Biology: Marine and Freshwater Biology
    - BS Biology: Microbiology
    - BS Biology: Cell and Molecular Biology

- BS Biology: Neurobiology
- BS Biology: Plant Biology
- BS Biology: Teaching
- BS Clinical Laboratory Science
- I'm double-majoring in biology and some other discipline
- I'm majoring in something else besides biology or I am Undeclared

Reasons for Leaving the Biology Major

22. What is your current school or college of enrollment?
    - Architecture
    - Business
    - Communication
    - Education
    - Engineering
    - Fine Arts
    - Geosciences
    - Graduate Studies
    - Information
    - Law
    - Liberal Arts
    - Natural Sciences
    - Nursing
    - Pharmacy
    - Social Work
    - Other (please specify)
23. What is your current major? _____
24. Just as students have multiple reasons for choosing a particular major, students also have multiple reasons for leaving their particular major. Please rate the following statements based upon how well they describe your reasons for leaving the biology major. If you had reasons for leaving the biology major besides the ones listed below, please describe and rate them in the next question.

    Rating Scale:

    1 = Not at all true of me
    2 = Slightly true of me
    3 = Moderately true of me
    4 = Very true of me
    5 = Completely true of me

    Items:

    I left the biology major because I preferred another discipline over biology

    I left the biology major because I would have better job opportunities with a degree in another discipline than with a degree in biology

    I left the biology major because I have gotten a better education my other courses than I did in my biology courses

I left the biology major because my other instructors were better or more effective teachers than the ones from the biology department
I left the biology major because I would make a better living with a degree in another discipline than with a degree in biology
I left the biology major because I lost interest in biology
I left the biology major because I grew to dislike biology
I left the biology major because I found out I have a higher aptitude for another discipline
I left the biology major because I felt that I did not belong or fit in the biology major
I left the biology major because I found out that I did not need to major in biology to prepare for or enter my chosen career
I left the biology major because a biology degree will not prepare me for what I want to do after college
I left the biology major because I lost interest in a career or profession for which biology was helpful or required
I left the biology major because I changed my mind about what I wanted to do after college
I left the biology major because my talents are best suited to another discipline besides biology
I left the biology major because it would have taken too long to finish a biology degree
I left the biology major because it would have taken too much money to finish a biology degree
I left the biology major because it would have taken too much effort to finish a biology degree
I left the biology major because the career opportunities in biology were not worth the time, money, or effort it would take to finish a biology degree
I left the biology major because I had difficulty handling the amount of work required in my biology courses
I left the biology major because I had difficulty handling the pace of my biology courses
I left the biology major because I had difficulty handling the amount of information I was expected to learn in my biology courses
I left the biology major because I felt that I could not succeed in biology
I left the biology major because someone encouraged me to change my major
I left the biology major because someone discouraged me from staying in the major
I left the biology major because I have learned more in my other courses than in my biology courses
I left the biology major because I did not like the way my biology courses were taught
I left the biology major because I did not like the way I was treated by my biology instructors
I left the biology major because I did not like my biology courses
I left the biology major because I did not like the learning experiences that my biology courses provided for me

I left the biology major because of the lack of support I received from my biology instructors
I left the biology major because of the lack of support I received from my biology advisor
I left the biology major because of the lack of support I received from my fellow biology students
I left the biology major because I performed poorly in biology
I left the biology major because I performed better in other courses than I did in biology courses
I left the biology major because biology was difficult for me
I left the biology major because I felt that biology was wrong for me
I left the biology major because I did not like the competitive nature of my biology courses
I left the biology major because I was more interested in other courses than my biology courses

25. Other reasons you decided to leave the biology major, not listed above:

_____

Reasons for Continuing in the Biology Major

26. Just as students have multiple reasons for choosing a particular major, students also have multiple reasons for continuing in that major. Please rate the following statements based upon how well they describe your reasons for continuing in the biology major. If you had reasons for staying in the biology major besides the ones listed below, please describe and rate them in the next question.

Rating Scale:
1 = Not at all true of me
2 = Slightly true of me
3 = Moderately true of me
4 = Very true of me
5 = Completely true of me

Items:
I have stayed in the biology major because I prefer biology over other disciplines
I have stayed in the biology major because I will have better job opportunities with a biology degree than with a degree in another discipline
I have stayed in the biology major because I am getting a better education in my biology courses than I have in my other courses
I have stayed in the biology major because my biology instructors are better or more effective teachers than ones from other departments
I have stayed in the biology major because I will make a better living with a biology degree than with a degree in another discipline
I have stayed in the biology major because I am still interested in biology
I have stayed in the biology major because I still like biology
I have stayed in the biology major because I have a higher aptitude for biology than for other disciplines

I have stayed in the biology major because I feel that I belong or fit in the biology major
I have stayed in the biology major because I need to major in biology to prepare for or enter my chosen career
I have stayed in the biology major because a biology degree will best prepare me for what I want to do after college
I have stayed in the biology major because I am still interested in a career or profession for which a biology degree is helpful or required
I have stayed in the biology major because I have not changed my mind about what I want to do after college
I have stayed in the biology major because my talents are best suited to biology
I have stayed in the biology major because it would have taken too long to finish a different degree
I have stayed in the biology major because it would have taken too much money to finish a different degree
I have stayed in the biology major because it would have taken too much effort to finish a different degree
I have stayed in the biology major because the career opportunities in other disciplines are not worth the time, money, or effort it would take to finish a degree in those disciplines
I have stayed in the biology major because I do not have difficulty handling the amount of work required in my biology courses
I have stayed in the biology major because I do not have difficulty handling the pace of my biology courses
I have stayed in the biology major because I do not have difficulty handling the amount of information I am expected to learn in my biology courses
I have stayed in the biology major because I feel that I can succeed in biology
I have stayed in the biology major because someone encouraged me to stay in the major
I have stayed in the biology major because someone discouraged me from leaving the major
I have stayed in the biology major because I have learned more in my biology courses than in my other courses
I have stayed in the biology major because I like the way my biology courses have been taught
I have stayed in the biology major because I like the way I have been treated by my biology instructors
I have stayed in the biology major because I like my biology courses
I have stayed in the biology major because I like the learning experiences that my biology courses have provided for me
I have stayed in the biology major because of the support I have received from my biology instructors
I have stayed in the biology major because of the support I have received from my biology advisors

I have stayed in the biology major because of the support I have received from my fellow biology students
I have stayed in the biology major because I perform well in biology
I have stayed in the biology major because I perform better in biology courses than I did in other classes
I have stayed in the biology major because biology is easy for me
I have stayed in the biology major because I feel that biology is right for me
I have stayed in the biology major because I like the competitive nature of my biology courses
I have stayed in the biology major because I am more interested in my biology courses than my other courses

27. Other reasons you decided to stay in the biology major, not listed above:

_____

Opinions of the Biology Major

Questions 28 through 31 removed; results not reported.

32. Please rate the following facilities and opportunities on how they affected your overall opinion of the biology major. A negative effect means that an item caused you to dislike the biology major; a positive effect means that an item caused you to like the biology major. If you have not experienced one of the following, please select N/A.

Ratings:
-3 = Highly negative effect
-2 = Moderately negative affect
-1 = Slightly negative effect
0 = Neutral; No effect
+1 = Slightly positive effect
+2 = Moderate positive effect
+3 = Highly positive effect
X = N/A

Items:
The biology classroom facilities, including desks, chairs, lighting, equipment, space, etc.
The learning environment of my biology classes
The biology laboratory facilities
The life science library facilities
The biology computer lab facilities
The opportunities for discussion during biology lectures
The opportunities for interaction with other students during biology lectures
The opportunities for discussion during biology discussions
The opportunities for interaction with other students during biology discussions
The availability of biology research opportunities

33. Please rate the following aspects of the biology advising you received on how they affected your overall opinion of the biology major. A negative effect means that an item caused you to dislike the biology major; a positive effect means that an item

caused you to like the biology major. If you have not experienced one of the following, please select N/A.
Ratings:
-3 = Highly negative effect
-2 = Moderately negative affect
-1 = Slightly negative effect
0 = Neutral; No effect
+1 = Slightly positive effect
+2 = Moderate positive effect
+3 = Highly positive effect
X = N/A
Items:
My biology advisors' knowledge of university policies and procedures
My biology advisors' knowledge of major requirements
My biology advisors' ability to help me choose courses
My biology advisors' ability to assist me with academic difficulties
My biology advisors' ability to assist me with non-academic difficulties
My biology advisors' attitude towards me
My biology advisors' attitude towards other students
My biology advisors' ability to adapt his/her general advice to me and my needs
My biology advisors' ability to give me individualized attention

34. Please rate the following aspects of your biology courses on how they affected your overall opinion of the biology major. A negative effect means that an item caused you to dislike the biology major; a positive effect means that an item caused you to like the biology major. If you have not experienced one of the following, please select N/A.
Ratings:
-3 = Highly negative effect
-2 = Moderately negative affect
-1 = Slightly negative effect
0 = Neutral; No effect
+1 = Slightly positive effect
+2 = Moderate positive effect
+3 = Highly positive effect
X = N/A
Items:
The biology exams
The grading policies or procedures in my biology courses
The precision which the biology exams tested my understanding of the material
The degree to which the biology exams reflected the material presented in lecture
The degree to which my biology grades reflected my understanding of the material
The overall learning experience provided by my biology courses
My grades in biology course(s)
My understanding of biology
The biology lecture(s)

The biology laboratory course(s)
The biology discussion section(s)

35. Please rate the following aspects of your biology instructors and TAs on how they affected your overall opinion of the biology major. A negative effect means that an item caused you to dislike the biology major; a positive effect means that an item caused you to like the biology major. If you have not experienced one of the following, please select N/A.

Ratings:
-3 = Highly negative effect
-2 = Moderately negative affect
-1 = Slightly negative effect
0 = Neutral; No effect
+1 = Slightly positive effect
+2 = Moderate positive effect
+3 = Highly positive effect
X = N/A

Items:
Biology instructors' ability to teach
Biology instructors' ability to manage the classroom
Biology instructors' ability to communicate information
Biology instructors' use of technology during lecture
Biology instructors' biology content knowledge
Biology instructors' helpfulness
Biology instructors' availability outside of class
Biology instructors' attitude towards me
Biology instructors' attitude towards students in general
Biology TAs' ability to teach
Biology TAs' ability to manage the classroom
Biology TAs' ability to communicate information
Biology TAs' use of technology during discussion
Biology TAs' biology content knowledge
Biology TAs' helpfulness
Biology TAs' availability outside of class
Biology TAs' attitude towards me
Biology TAs' attitude towards students in general

Question 36 removed; results not reported.

If you are interested in being considered for interviews and/or focus groups about your experiences in biology, please enter your email address in the space provided. Please note that you will be monetarily compensated for both interviews and focus groups and I will not use your email except to contact you about future participation. If you are not interested, please click "Continue with Survey"

Thanks so much for taking the time to complete this questionnaire!

APPENDIX B: LIFE STORY INTERVIEW PROTOCOL, SWITCHERS

The purpose of these interview questions is to help you tell the story of your life in science, from your first memory of science to the present. Between now and the time of our interview, please review these questions and either jot down some things you may want to tell me about during the interview, or, if you are so inclined, use these questions to write a story about yourself. Please note that you can address ANY experiences you had in science, even if they took place outside of a classroom.

1) Thinking back to your childhood, what is your first memory of science? This can be the first time you remember learning or experiencing something scientific or it could be the first time you remember liking or being interested in science.
2) How did your earlier experiences with science (childhood through high school) shape your interest in science and/or biology?
3) What was your worst experience in high school science? What was your best experience in high school science?
4) How did you come to decide to major in biology? What was your thought process? How were other people involved in this decision? What events or experiences were involved in this decision?
5) What was it like to be a biology student? Tell the story of your experiences in the biology major. You may want to think about this question year by year, either starting from the beginning and working forward, or starting from your most recent experience and working backwards.
6) What was your worst experience in college science? What was your best experience in college science? Note that this may or may not be about biology (see #7).
7) What was your worst experience in college biology? What was your best experience in college biology?
8) What obstacles did you have to deal with as a biology major? How did you deal with those obstacles?
9) Most college students go through a period in which they are uncertain that they have chosen the right major or career path. What was happening the first time you had second thoughts about majoring in biology?
10) How did you come to decide to leave the biology major? What was your thought process? What people were involved in this decision? What events or experiences were involved in this decision?
11) How did your performance in your biology courses figure into your decision to leave the biology major?
12) How are you similar to the students who end up staying in the biology major? How are you different from students who end up staying in the biology major?
13) What do you think is most important in determining a student's success in biology?
14) What have you learned about yourself as a result of your experiences in college?

APPENDIX C: LIFE STORY INTERVIEW PROTOCOL, PERSISTERS

The purpose of these interview questions is to help you tell the story of your life in science, from your first memory of science to the present. Between now and the time of our interview, please review these questions and either jot down some things you may want to tell me about during the interview, or, if you are so inclined, use these questions to write a story about yourself. Please note that you can address ANY experiences you had in science, even if they took place outside of a classroom.

1) Thinking back to your childhood, what is your first memory of science? This can be the first time you remember learning or experiencing something scientific or it could be the first time you remember liking or being interested in science.
2) How did your early experiences with science (childhood through high school) shape your interest in science and/or biology?
3) What was your worst experience in high school science? What was your best experience in high school science?
4) How did you come to decide to major in biology? What was your thought process? How were other people involved in this decision? What events or experiences were involved in this decision?
5) What has it been like to be a biology student? Tell the story of your experiences in the biology major. You may want to think about this question year by year, either starting from the beginning and working forward, or starting from your most recent experience and working backwards.
6) What has been your worst experience in college science? What has been your best experience in college science? Note that may or may not be about biology (see #7).
7) What has been your worst experience in college biology? What has been your best experience in college biology?
8) What obstacles have you had to deal with as a biology major? How did you deal with those obstacles?
9) Most college students go through a period in which they are uncertain that they have chosen the right major or career path. Was there ever a time that you had second thoughts about majoring in biology? What was happening at that time?
10) Over half of students initially committed to the biology major do not get a biology degree. How did you come to decide to continue in the biology major? What was your thought process? What people were involved in this decision? What events or experiences were involved in this decision?
11) How did your performance in your biology courses figure into your decision to continue in the biology major?
12) How are you similar to the students who end up leaving the biology major? How are you different from students who end up leaving the biology major?
13) What do you think is most important in determining a student's success in biology?
14) What have you learned about yourself as a result of your experiences in college?

APPENDIX D: EXAMPLE FINAL LIFE STORY INTERVIEW PROTOCOL

The purpose of these interviews is to uncover your life in science. To that end, I will be asking you the general questions that I supplied over email, as well as ask you to elaborate on some of your responses on the questionnaire. Please be aware that I am not just asking about your formal experiences in science (i.e. those that took place in school). If you have informal experiences or ones that took place in other contexts besides school, those are of interest to me as well.

Background of student:

1) **Warm Up:** To begin the interview, I would like you to do a bit of time traveling. Please close your eyes and think back to when you first remember being interested in science. How old were you? What were you doing at the time? Who else was there? What were they doing? What did you feel at the time?
2) **Childhood experiences in science:** How did your earlier experiences with science (childhood through high school) shape your interest in science and/or biology?
    a) Using this earliest memory as a jumping off point, tell me about your other childhood experiences in science.
        i) Suppose I was present with you during this time, what would I see going on? What would you be doing?
        ii) You mentioned in your questionnaire that **having a family member or mentor who worked in the health professions** was important in developing your interest in biology. Can you tell me more about that experience?
        iii) You mentioned in your questionnaire that **having a family member or mentor who majored in the biological sciences** was important in developing your interest in biology. Can you tell me more about that experience?
3) **Adolescent / High School experiences in science**
    a) Beginning with your first high school science course, tell me about your high school experiences in science.
        i) Suppose I was present with you in your high school biology course(s), what would I see going on? What would you be doing? What would your teacher be doing? What would other students be doing?
        ii) You mentioned in your questionnaire that **your good performance in your high school biology courses** was important in developing your interest in biology. Can you tell me more about that experience?
        iii) What was your worst experience in high school science?
        iv) What was your best experience in high school science?
4) **Choosing the biology major**
    a) How did you decide to major in biology? What was the thought process involved? What people were involved? What events or experiences were involved?
        i) You mentioned in your questionnaire that **your desire to help people** was important in your decision to choose biology as a major. Can you tell me more about this?

(1) There are many ways to help people. How did you decide that being in a **health profession** was the way you wanted to do this?

ii) You mentioned in your questionnaire that **performing well in high school biology** was important in your decision to choose biology as a major. Can you tell me more about how you became interested in this?

iii) You mentioned in your questionnaire that you majored in biology because **you thought biology was the best degree to have for professional school**. Can you tell me more about how you became interested in this?

iv) You mentioned in your questionnaire that you majored in biology because **you thought biology would best prepare you for your chosen career**. Can you tell me more about how you became interested in this?

v) You mentioned in your questionnaire that your interest in **evolutionary biology** was important in your decision to choose biology as a major. Can you tell me more about how you became interested in this?

b) Suppose I am a high school senior, deciding whether or not I should major in biology, what would you tell me?

c) Suppose you could go back to the time during which you were deciding your major, what would you do differently and what would you do the same?

5) **College experiences in science**

a) What was it like to be a biology student? Tell the story of your experiences in the biology major. You may want to think about this question year by year, either starting from the beginning and working forward, or starting from your most recent experience and working backwards.

i) Suppose I was present with you in your introductory biology course(s), what would I see going on? What would you be doing? What would your instructor be doing? What would other students be doing?

ii) If I were to follow you through a typical week as an introductory biology student at UT, what would I see you doing?

iii) What was your worst experience in college science?

iv) What was your best experience in college science?

v) What was your worst experience in college biology?

vi) What was your best experience in college biology?

vii) You mentioned in your questionnaire that your **college biology instructors** greatly encouraged your interest in biology. Can you elaborate on this?

viii) On the questionnaire, you rated **the discussions, the opportunities for discussion and interaction with other students during biology discussions as poor**. Can you elaborate on this?

ix) On the questionnaire, you demonstrated a very low opinion of the **advising** you received while you were in the biology major. Can you elaborate on this?

(1) You rated the following as POOR

(a) Knowledge of university policies and procedures

(b) Knowledge of major requirements

(c) Ability to help me choose courses

(d) Ability to adapt his/her general advice to me and my needs

x) On the questionnaire, you demonstrated a very high opinion of the **teaching** you received while you were in the biology major. Can you elaborate on this?
(1) You rated the following as EXCELLENT
(a) Ability to teach
(b) Ability to manage the classroom
(c) Ability to communicate information
(d) Attitude towards me
(e) Attitude towards students in general

b) What obstacles have you had (did you have) to deal with as a biology major?
i) How did you deal with those obstacles?
ii) Suppose you could go back in time, how would you handle those situations knowing what you know now?

c) Most college students go through a period in which they are uncertain that they have chosen the right major or career path. What was happening the first time you had second thoughts about majoring in biology?

d) Suppose I was a first-semester freshman majoring in biology at UT, what would you tell me?

6) **Leaving the biology major**

a) How did you come to decide to leave the biology major? What was the thought process involved? What people were involved? What events or experiences were involved?
i) You mentioned in the questionnaire that you left the biology major because **you would have better job opportunities/make a better living with a degree in another discipline than with a degree in biology.** Can you elaborate on this?
ii) You mentioned in the questionnaire that you left the biology major because **the career opportunities in biology were not worth the time, money or effort it would take to finish a biology degree.** Can you elaborate on this?
iii) You mentioned in the questionnaire that you left the biology major because **your talents were best suited to another discipline besides biology**. Can you elaborate on this?
iv) How did your performance in your biology courses figure into your decision to leave the biology major?

b) What do you think of students who continue in the biology major?
i) How are you different from the students who continue in the biology major?
ii) How are you similar to the students who continue in the biology major?

c) How did those closest to you react to your decision to switch majors?

d) What do you want to do after college?
i) Nursing/Premed: Do you still plan to go to medical school?

7) **Ideas of success**

a) What do you think is most important in determining a student's success in biology?
i) You mentioned in the questionnaire that **being good at taking tests** is important in determining a students' success in biology. Can you elaborate on that?

ii) You mentioned in the questionnaire that **taking biology courses with instructors who are interested in teaching, who are enthusiastic about biology, who are interested in their students, and who want their students to succeed** is important in determining a students' success in biology. Can you elaborate on that?

b) How do you define academic success?

8) **Conclusion**
   a) What have you learned about yourself as a result of your experiences in college?
   b) This covers the things I wanted to ask. Is there anything you care to add? What should I have asked you that I did not think to ask?

9) **Additional Demographic questions**
   a) What year did you graduate from high school?
   b) Did you take off any time between high school and college or during college?

APPENDIX E: FOCUS GROUP INTERVIEW PROTOCOL, SWITCHERS

1) To open up the discussion, I would like you to spend a few minutes thinking about your time in the biology major. Think about the classes you took, the people you met and worked with, the experiences you had, both in and out of the classroom, and the things you liked and the things you didn't like about the biology major. When you're ready, take five of the index cards in front of you and, on each index card write down up to five separate words or phrases that describe your experiences as a biology student.
    a. When you're done, post your cards up on the wall vertically.
    b. Study all of the responses and organize any that are similar
    c. Going around the circle, tell me what your words or phrases mean to you
    d. Follow up questions/discussion
2) What made it harder or more difficult for you as a biology student?
3) What made it easier for you as a biology student?
4) Now we're going to go back in time, to when you were choosing biology as your major. Think about how you made the decision and what was going on at the time.
    a. When you're ready, take five more of the index cards in front of you, and on a separate index card write down up to five reasons you chose biology as your major.
    b. When you're done, study your cards and rank them in order of importance, from 1 (most important) to 5 (least important).
    c. Post your cards up on the wall vertically, from most to least important.
    d. Going around the circle, tell me about your reasons, and why you ranked them the way you did.
    e. Follow up questions/discussion
5) Now we've talked about your reasons for choosing biology, let's talk about your motivation. There is a subtle difference between a reason and a motivation. Although both can be causes for an action, a reason is a justification or explanation for an action, while a motivation is the stimulus or desire that induces that action. A reason explains a particular path, while a motivation starts you on the path. What was your motivation for choosing biology as a major? In other words, what first set you on the path towards getting your biology degree?
6) Think back to your first semester of college. Where did you see yourself after graduation? What has changed since then?
7) Over half of the students who enter the biology major do not earn a biology degree. This means that the odds of finishing a biology degree are not in a student's favor. The students who leave report either that they left because they had specific experiences that caused them to leave (or kept them from staying) or because they had specific experiences that led them to believe they had chosen the wrong major.

    a. When you're ready, take five more of the cards in front of you and on a separate index card, write down up to five pieces of evidence that either caused you to

leave the biology major or led you to believe that you had chosen the wrong major.

b. When you're done, study your cards and rank them in order of importance, from 1 (most important) to 5 (least important).
c. Post your cards up on the wall vertically, from most to least important.
d. Going around the circle, tell me about these pieces of evidence, why you ranked them the way you did, and whether these pieces of evidence caused you to leave or led you to believe that you had chosen the wrong major.
e. Follow up questions/discussion

8) This covers everything I wanted to ask you. Is there anything that you want to mention, or something that you wrote down on a card that you would like to elaborate on?

APPENDIX F: FOCUS GROUP INTERVIEW PROTOCOL, PERSISTERS

1) To open up the discussion, I would like you to spend a few minutes thinking about your time in the biology major. Think about the classes you've taken, the people you've met and worked with, the experiences you've had, both in and out of the classroom, and the things you've liked and the things you haven't liked about the biology major.
    a. When you're ready, take five of the index cards in front of you and, on a separate index card write down up to five words or phrases that describe your experiences as a biology student.
    b. When you're done, post your cards up on the wall vertically.
    c. Study all of the responses and organize any that are similar
    d. Going around the circle, tell me what your words or phrases mean to you
2) What has made it harder or more challenging for you as a biology student?
3) What has made it easier for you as a biology student?
4) Now we're going to go back in time, to when you were choosing biology as your major. Think about how you made the decision and what was going on at the time.
    a. When you're ready, take five more of the index cards in front of you, and on a separate index card write down up to five reasons you chose biology as your major.
    b. When you're done, study your cards and rank them in order of importance, from 1 (most important) to 5 (least important).
    c. Post your cards up on the wall vertically, from most to least important.
    d. Going around the circle, tell me about your reasons, and why you ranked them the way you did.
    e. Follow up questions/discussion
5) Now we've talked about your reasons for choosing biology, let's talk about your motivation. There is a subtle difference between a reason and a motivation. Although both can be causes for an action, a reason is a justification or explanation for an action, while a motivation is the stimulus or desire that induces that action. A reason explains a particular path, while a motivation starts you on the path. What was your motivation for choosing biology as a major? In other words, what first set you on the path towards getting your biology degree?
6) Think back to your first semester of college. Where did you see yourself after graduation? What has changed since then?
7) Over half of the students who enter the biology major do not earn a biology degree. This means that the odds of finishing a biology degree are not in a students' favor. The students who stay report either that they stayed because they had specific experiences that actively caused them to stay (or kept them from leaving) or because they had specific experiences that confirmed that they had made the right choice of major.
    a. When you're ready, take five more of the cards in front of you and on a separate index card, write down up to five pieces of evidence that either helped you stay in the major or confirmed that you made the right decision to major in biology.

b. When you're done, study your cards and rank them in order of importance, from 1 (most important) to 5 (least important).
c. Post your cards up on the wall vertically, from most to least important.
d. Going around the circle, tell me about these pieces of evidence, why you ranked them the way you did, and whether these pieces of evidence kept you from leaving or confirmed your major choice.
e. Follow up questions/discussion

8) This covers everything I wanted to ask you. Is there anything that you want to mention, or something that you wrote down on a card that you would like to elaborate on?

APPENDIX G: INTERVIEW ADDENDUM

Interview #:
Date Completed:

Please read through the interview and check the accuracy of the meaning of what you said. If there are any corrections to the wording that you feel are necessary, for example, you said something that is not quite an accurate representation of what you are thinking; please list that as a **Correction**. **Please note that you are not to correct your word usage or vocal tics (such as "like," "you know," etc.), unless they alter the meaning of what you said.** If you've remembered something else that you did not mention during the interview, or if you would like to further explain something you said in the interview; please list that as an **Addition**. **For each of these sections, list the line # where the correction or addition should go and then write the complete correction or addition you are making (see simple examples below).** If you need additional space in a particular box, please hit return to make the writing space larger (this will probably happen automatically if you keep writing). If you need additional lines, put your cursor in the bottom left box and, using the Table menu, go to Insert and then Lines below (or hold down the alt button and hit A, then I, then B, in that order). **If you have no corrections or additions to make, enter N/A in the first Correction and the first Addition box, so that I have verification of this. You may write over the example corrections.**

Line #	Correction
44	I should have said: "My 7th grade science teacher…" (not 8th grade)

Line #	Addition
45	My 8th grade science teacher was absolutely horrible. He just sat up at the front of the room and gave us worksheets. I don't think I learned anything.

APPENDIX H: FINAL CODE LIST

The following coding list is organized in the following manner:

1) Code
    a) Sub-Code
        i) Infra-Code

Codes:

1) First memory of science
    a) Family-centered
    b) School-centered
2) Precollege experiences
    a) High school biology
    b) Educational television
    c) Science fair participation
    d) Informal science experience
    e) Family member with illness
    f) Being a patient
    g) Reading about science
    h) Health profession internship
3) Introductory high school science experiences
    a) Biology I
        i) Positive
        ii) Negative
    b) Chemistry I
        i) Positive
        ii) Negative
    c) Physics I
        i) Positive
        ii) Negative
4) Precollege sources of encouragement
    a) High school biology teacher
    b) Parent or guardian
        i) Mother or female guardian
        ii) Father or male guardian
    c) Other significant adult
    d) Sibling(s)
    e) Middle school science teacher
5) Choosing biology
    a) High school biology
    b) Interest in biology
    c) Parents
        i) Influence
        ii) Modeling

iii) Support
d) Helping others
e) Lack of interest in other disciplines
f) Medical school
i) Default
ii) Preparation
iii) Convenience/coincidence
g) Ignorance
h) Appearance
i) Job options
j) Inspiration
k) Biology easy
l) Familiarity
m) Biology broad
n) Friends
o) Biology challenging
p) Avoidance of math
q) Necessary

6) First year science experiences
a) 1st semester biology
i) Positive
ii) Negative
b) 2nd semester biology
i) Positive
ii) Negative
c) 1st semester chemistry
i) Positive
ii) Negative
d) 2nd semester chemistry
i) Positive
ii) Negative

7) Biology Advisors
a) Type of experience
i) Positive
ii) Negative
iii) Both positive and negative
b) Perceptions of biology advisors
i) Helped me
ii) Offered generic advice
iii) Treated me like a number
iv) Gave me incorrect information
v) Advised me to reconsider/change major

8) Biology Faculty
a) Challenging
b) Exacting

c) Caring
d) Indifferent
e) Engaging
f) Uninspiring
g) Welcoming
h) Unwelcoming
i) Student-interested
j) Self-interested
k) Knowledgeable
l) Incompetent

9) Peers
   a) Competition
      i) Feelings of inadequacy
      ii) Feelings of exclusion
      iii) Getting off of premed track
      iv) Not participating in organizations or biology major functions
      v) Inspired to do better
   b) Relationships
      i) Partnership
      ii) Friendship
      iii) Comradeship
   c) Cohort groups
      i) Access to study partners
      ii) Making friends
      iii) Not fitting in
      iv) Feeling excluded
      v) Liked smaller size
      vi) Disliked smaller size

10) Staying in biology
   a) Not Wanting to Give Up or Give In
   b) Enjoyment of Biology
   c) Continued Interest in Biology
   d) Good Performance in Biology
   e) Particular Course Experience
   f) Working in Biology
   g) Not Interested in Other Options
   h) Personal Encouragement
   i) Friends/Feelings of Belonging
   j) Liking Future Career Options
   k) Liking the Challenge
   l) Never Considered Leaving
   m) Doing Important Work after Graduation
   n) Double-majoring with a Non-Science Degree
   o) Impressing Others
   p) Did Not Take Science Freshman Year

q) Focus on a Career Connected to the Major
r) Not Disappointing Parents
s) Pursuing a BA rather than a BS in biology
t) Switching to Another Major
u) AP Credit for Introductory Biology
v) Better Preparation for Medical School
w) Combination of n, p, s, t, and u = Having other stuff to do

11) Leaving biology
a) Difficulties with Workload
b) Not Interested in Jobs Connected to Biology
c) Not Belonging/Fitting In
d) Not Interested in Biology
e) Personal Encouragement to Switch Majors
f) Poor Performance in Courses Required for Major
g) No Longer Going to Medical School
h) Exposure to Another Discipline while in College
i) Not Learning Enough
j) Other Interest Besides Biology
k) Financial Concerns
l) Lack of Mentors
m) Not Liking Biology
n) Personal Discouragement from Staying in Biology

12) Second thoughts
a) No second thoughts
b) Grade point average
c) Difficulties during first semester
d) Other students leaving the major
e) Taking a non-biology course
f) Fear of burnout before medical school
g) Always had second thoughts

13) Role of performance in persistence
a) Good
i) No effect
ii) Confirmation
b) Poor
i) Inspired to try harder
ii) No effect

14) Role of performance in departure
a) Good
i) No effect
ii) Not competitive enough
b) Poor
i) Reason for leaving the major

Glossary

Biology persister – a biology student who persists in the biology major

Biology switcher – a biology student who leaves the biology major

Non-STEM switcher – a biology student who leaves for a non-STEM major

Non-switcher – same as a persister, used by some authors

Other STEM switcher – a biology student who leaves for a different STEM major

Persister – a STEM student who persists in their chosen STEM major

STEM – science, technology, engineering, and math

Switcher – a STEM student who leaves their chosen STEM major

Bibliography

Abdi, H (2007). Bonferroni and Sidak corrections for multiple comparisons. In Salkind, N. J. (ed.), *Encyclopedia of Measurement and Statistics*. Thousand Oaks, CA: Sage.

American Association for the Advancement of Science (AAAS). (2005). *Science for all Americans: education for a changing future.* Retrieved November 1, 2005, from http://www.project2061.org/publications/sfaa/default.htm.

American Psychological Association. (2001). *Publication Manual of the American Psychological Association.* (5th ed.). Washington, DC: APA.

Astin, A. W. (1985). *Achieving Academic Excellence.* San Francisco: Jossey-Bass.

Astin, A.W. & Astin, H.S. (1993). *Undergraduate science education: the impact of different college environments on the educational pipeline in the sciences.* Los Angeles: Higher Education Research Institute. (ERIC Document Reproduction Service No. ED362404).

Atkinson, R. (1998). *The Life Story Interview: Qualitative Research Methods Series 44.* Thousand Oaks, CA: Sage.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, *84* (2), 191-215.

Bandura, A. (1995). Exercise of personal and collective efficacy in changing societies. In Bandura, A. (ed.), *Self-Efficacy in Changing Societies*. New York: Cambridge University Press.

Bandura, A. (1997). *Self-Efficacy: The Exercise of Control*. New York: WH Freeman and Company.

Bean, J. (1980). Dropouts and turnover: The synthesis and test of a casual model of student attrition. *Research in Higher Education, 12*, 155-187.

Bean, J. (1983). The application of a model of turnover in work organizations to the student attrition process. *The Review of Higher Education*, *6*, 129-148.

Bland, J.M. & Altman, D.G. (2000). The odds ratio. *British Medical Journal, 320*, 1468.

Braxton, J.M. & Lien, L.A. (2000). The viability of academic integration as a central construct in Tinto's interactionalist theory of college student departure. In Braxton, J.M. (ed.) *Reworking the Student Departure Puzzle*. Nashville, TN: Vanderbilt University.

Brooks, R. (2007). Friends, peers, and higher education. *British Journal of the Sociology of Education, 28* (6), 693-707.

Bureau of Health Professions. (2003). *Changing demographics: implications for physicians, nurses, and other health workers.* Retrieved November 1, 2005, from http://bhpr.hrsa.gov/healthworkforce/reports/changedemo/default.htm.

Canes, B.J. & Rosen, H.S. (1995). Following in her footsteps? Faculty gender composition and women's choices of college major. *Industrial and Labor Relations Review*, *48* (3), 486-504.

Center for Institutional Data Exchange and Analysis (C-IDEA). (2000). *1999-2000 SMET Retention Report.* Norman, OK: University of Oklahoma.

College of Natural Sciences (2006a). [Tracking data for freshmen who entered the biology major between Fall 2000 and Fall 2005]. The University of Texas at Austin. Unpublished raw data.

College of Natural Sciences (2006b). [Tracking data for students who graduated with a biology degree between December 2003 and August 2006]. The University of Texas at Austin. Unpublished raw data.

Dye, J.F., Schatz, I.M., Rosenberg, B.A. & Coleman, S.T. (2000). Constant comparative method: a kaleidoscope of data. *The Qualitative Report, 4* (1-2). Retrieved August 15, 2007, from http://www.nova.edu/ssss/QR/QR4-1/dye.html

Eng, J. (2003). Sample size estimation: how many individuals should be studied? *Radiology*, *227* (2), 309-313.

Eyster, K.M. (2007). Career counseling: 101+ things you can do with a degree in biology. *Advances in Physiology Education*, *31*, 323-328.

Feldman, K.A., Smart, J.C., & Ethington, C.A. (1999). Major field and person-environment fit: using Holland's theory to study change and stability of college students. *Journal of Higher Education*, *70* (6), 642-669.

Feldman, K.A., Smart, J.C., & Ethington, C.A. (2001). A further investigation of major field and person-environment fit: sociological versus psychological interpretations of Holland's theory. *Journal of Higher Education, 72*(6), 670-698.

Field, A. (2005). *Discovering Statistics Using SPSS: (and sex, drugs and rock 'n' roll).* Thousand Oaks, CA: Sage.

Fishbein, M. & Azjen, I. (1975). *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research*. Reading, MA: Addison-Wesley.

Gibbons, J. D. & Chakraborti, S. (2003). *Nonparametric Statistical Inference.* (4th Ed.). New York: Marcel Dekker.

Green, K.C. (1989). A profile of the undergraduates in the sciences. *The American Scientist*, *78*, 475-480.

Hosmer, D. W. & Lemeshow, S. (1999). *Applied Survival Analysis: Regression Modeling of Time to Event Data*. New York: John Wiley & Sons.

Hu, N.B. (1996). *Effects of college students' perceptions of labor market variables and conditions on their choice of academic majors.* Albuquerque, NM: Annual Forum of the Association for Institutional Research. (ERIC Document Reproduction Service No. ED397708).

Ingersoll, R.M. (2003a). Is there really a teacher shortage? *Center for the Study of Teaching and Policy*. Retrieved November 1, 2005, from http://mccte.educ.msu.edu/news/policy/other/Shortage-RI-09-2003.pdf

Ingersoll, R.M. (2003b). Out-of-field teaching and the limits of teacher policy. *Center for the Study of Teaching and Policy.* Retrieved November 1, 2005, from http://www.teaching-point.net/Out%20of%20Field%20Teaching.pdf.

Ishitani, T.T. (2003). A longitudinal approach to assessing attrition behavior among first generation students: time-varying effects of precollege characteristics. *Research in Higher Education, 44* (4), 433-449.

Johnson, B. & Christensen, L. (2004). *Educational Research: Quantitative, Qualitative and Mixed Approaches.* (2nd Ed.). New York: Pearson.

Kline, R.B. (2004). *Beyond Significance Testing: Reforming Data Analysis Methods in Behavioral Research.* Washington, DC: American Psychological Association.

Lang, S. A. (2004). *An Exploratory Study of the Motivation, Strategy Use and Major Choice of First-Year Students Enrolled in Introductory Biology.* Unpublished master's thesis, University of Texas at Austin.

Lee, E.T. (1992). *Statistical Methods for Survival Data Analysis*. (2nd Ed.). New York: John Wiley & Sons.

Lincoln, Y.S. & Guba, E.G. (1985). *Naturalistic Inquiry.* Thousand Oaks, CA: Sage.

Litoselliti, L. (2003). *Using Focus Groups in Research.* London: Continuum.

Lowell, B.L. & Salzman, H. (2007). *Into the Eye of the Storm: Assessing the Evidence on Science and Engineering Education, Quality, and Workforce Demand.* Washington, DC: The Urban Institute. Retrieved December 15, 2007 from http://www.urban.org/publications/411562.html

Manis, J.M., Sloat, B.F., Thomas, N.G., & Davis, C. (1989). *An analysis of factors affecting choices of majors in science, mathematics, and engineering at the University of Michigan.* Ann Arbor, MI: Center for Continuing Education of Women. (ERIC Document Reproduction Service No. ED356954).

Maxwell, J.A. (1992). Understanding and validity in qualitative research. *Harvard Educational Review, 62*, 279-299.

McDonald, P.L. & Gardner, R.C. (2000). Type I error rate comparisons of post hoc procedures for I j chi-square tables. *Educational and Psychological Measurement*, *60* (5), 735-754.

Micceri, T. (2005). *Investigating characteristics that typify engineering, computer and biological science graduates, the differences that occur among and between these disciplines and the general population of SUS graduates.* Tampa: University of South Florida (ERIC Document Reproduction Service No. ED497439).

National Science Foundation. (2003). *Characteristics of Recent Science and Engineering Graduates: 2003*. Arlington, VA: National Science Foundation.

National Science Board. (2008). Higher education in science and engineering. In *Science and Engineering Indicators 2008.* Arlington, VA: National Science Foundation.

Office of Institutional Research (2007a). Degrees conferred by college, level, ethnicity and gender. *2006-2007 Statistical Handbook.* Retrieved December 1, 2007, from http://www.utexas.edu/academic/oir/statistical_handbook/06-07/pdf/0607degrees.pdf

Office of Institutional Research (2007b). Fifteen largest undergraduate majors. *2006-2007 Statistical Handbook.* Retrieved December 1, 2007, from http://www.utexas.edu/academic/oir/statistical_handbook/06-07/pdf/0607students.pdf

Office of Institutional Research (2007c). Student flow for first-time freshmen. *2006-2007 Statistical Handbook.* Retrieved December 1, 2007, from http://www.utexas.edu/academic/oir/statistical_handbook/06-07/pdf/0607students.pdf

Office of Postsecondary Education (2007). Nationwide listing 1990-91 thru 2006-2007. *Teacher Shortage Areas.* Retrieved December 1, 2007, from http://www.ed.gov/about/offices/list/ope/pol/tsa.pdf

Office of the Registrar (2005). Advising and major codes. *Course Schedule Fall 2005*. Retrieved November 1, 2005, from, http://www.utexas.edu/student/registrar/schedules/059/tellme/advising.html

Onwuegbuzie, A.J. (2001). Effect sizes in qualitative research: a prolegomenon. *Quality & Quantity, 37*, 393-409.

Onwuegbuzie, A.J. & Leech, N. (2007). Validity and qualitative research: an oxymoron? *Quality & Quantity, 41*, 233-249.

Onwuegbuzie, A. J. & Teddlie, C. (2003). A Framework for Analyzing Data in Mixed Methods Research. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of Mixed Methods in Social & Behavioral Research.* Thousand Oaks, CA: Sage.

Packard, B.W. (2005). Mentoring and retention in college science: reflections on the sophomore year. *Journal of College Student Retention: Research, Theory and Practice,* 6 (3), 289-300.

Patton, M.Q. (2002). *Qualitative Research and Evaluation Methods*. (3rd Ed.). Thousand Oaks, CA: Sage.

Porter, S.R., & Umbach, P.D. (2006). College major choice: An analysis of person-environment fit. *Research in Higher Education, 47*, 429–449.

Princeton Review (2007). Ten most popular majors. Retrieved on October 10, 2007. http://www.princetonreview.com/college/research/articles/majors/popular.asp

Puchta, C. & Potter, J. (2004). *Focus Group Practice.* London: Sage.

Rask, K.N. & Bailey, E.M. (2002). Are faculty role models? Evidence from major choice at an undergraduate institution. *Journal of Economic Education*, *Spring*, 99-124.

Ryan, M. (1984). Conceptions of prose coherence: Individual differences in epistemological standards. *Journal of Educational Psychology, 76*(6): 1226-1238.

Seastrom, M.M., Gruber, K.J., Henke, R., McGrath, D.J., and Cohen, B.A. (2002). Qualifications of the public school teacher workforce: prevalence of out-of-field teaching, 1987–88 to 1999–2000. In *U.S. Department of Education, NCES 2002–03.* Washington, DC: National Center for Education Statistics.

Seymour, E. & Hewitt, N.M. (1997). *Talking about Leaving: Why Undergraduates Leave the Sciences.* Boulder, CO: Westview Press.

Siegel, S. (1956). *Nonparametric Statistics for the Behavioral Sciences: International Student Edition.* Tokyo: McGraw-Hill International.

Smyth, F.L. & McArdle, J.J. (2004). Ethnic and gender differences in science graduation at selective colleges with implications for admission policy and college choice. *Research in Higher Education. 45* (4), 353-381.

Stage, F.K. & Hossler, D. (2000). Where is the student? Linking student behaviors, college choice, and college persistence. In Braxton, J.M. (ed.), *Reworking the Student Departure Puzzle*. Nashville, TN: Vanderbilt University.

Statistical Package for the Social Sciences (SPSS Version 14.0). [Computer software]. Retrieved from http://wts-spss.austin.utexas.edu.

Statistical Package for the Social Sciences (SPSS Version 15.0). [Computer software]. Retrieved from http://wts-spss.austin.utexas.edu.

Strenta, C., Rogers, E., Russell, A., Matier, M., and Scott, J. (1994). Choosing and leaving science in highly selective institutions. *Research in Higher Education*, 35 (5), 513-547.

Texas Education Agency (2005). Minimum High School Program. Retrieved November 1, 2005 from: http://www.tea.state.tx.us/rules/tac/chapter074/ch074e.html

Tinto, V. (1993). *Leaving College: Rethinking the Causes and Cures of Student Attrition.* Chicago: The University of Chicago Press.

Tobias, S. (1990). *They're Not Dumb, They're Different: Stalking the Second Tier.* Tucson, AZ: Research Corporation.

Trautwein, U. & Lüdtke, O. (2007). Epistemological beliefs, school achievement, and college major: A large-scale, longitudinal study on the impact of certainty beliefs. *Contemporary Educational Psychology*, *32*, 348-366.

Trusty, J. (2002). Effects of high school course choice and other variables on choice of science and mathematics college majors. *Journal of Counseling and Development, 80*, 464-474.

Turner, S.E. & Bowen, W.G. (1999). Choice of major: The changing (and unchanging) gender gap. *Industrial and Labor Relations Review*, *52* (2), 289-313.

Uno, G.E. & Bybee, R.W. (1994). Understanding the dimensions of biological literacy. *Bioscience, 71* (8), 553-557.

Vita

Sarah Adrienne Lang was born in Duluth, Minnesota on September 23, 1973 8:38pm CDT, the daughter of Anita Elizabeth Lang and Paul Ernest Lang. She attended St. Martin Hall in San Antonio, Texas from 1977 to 1987 and Health Careers High School from 1987 to 1991. After graduating from high school, she entered Bryn Mawr College in Bryn Mawr, Pennsylvania, from which she earned a Bachelor of Arts in History in May 1995. Following three years of employment in the clinical laboratory industry, she earned a Bachelor of Science in Zoology in August 2000, and then a Master of Arts in Science Education in December 2004. While in graduate school, she worked for the UT School of Biological Sciences as a teaching assistant for introductory biology and upper-division microbiology from fall 2001 to spring 2007, as well as the supervisor for the biology leg of the Supplemental Instruction Program offered through the UT Learning Center from 2002 to 2005. Sarah is currently employed at UT Learning Center as a Program Coordinator for the Teaching Teams and Supplemental Instruction Programs.

Permanent address: 7502 Paxton St, Austin, Texas 78752

This dissertation was typed by the author.